MECHANICAL ENGINEERING

INCLUDING THE ENGINEERING INDEX

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

The Man for the Job

One weak point in every democracy, particularly when poorly understood and practised, is the belief among those who control political patronage that any man can do any job as well as any other man. The scientific man believes that a man must be trained for the job; hence his profound respect for the expert. Nothing in his opinion will advance our national strength and well-being so much as the ability of enlightened public opinion to differentiate between the expert and the clumsy product of political patronage. A motto of the Allies in the World War was: make the world safe for democracy. . . . It is even more important to "make democracy safe for the world" by the dissemination of scientific knowledge for the benefit of national strength and well-being.

MICHAEL PUPIN

(in "From Immigrant to Inventor")

APRIL 1924

THE MONTHLY JOURNAL PUBLISHED BY THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

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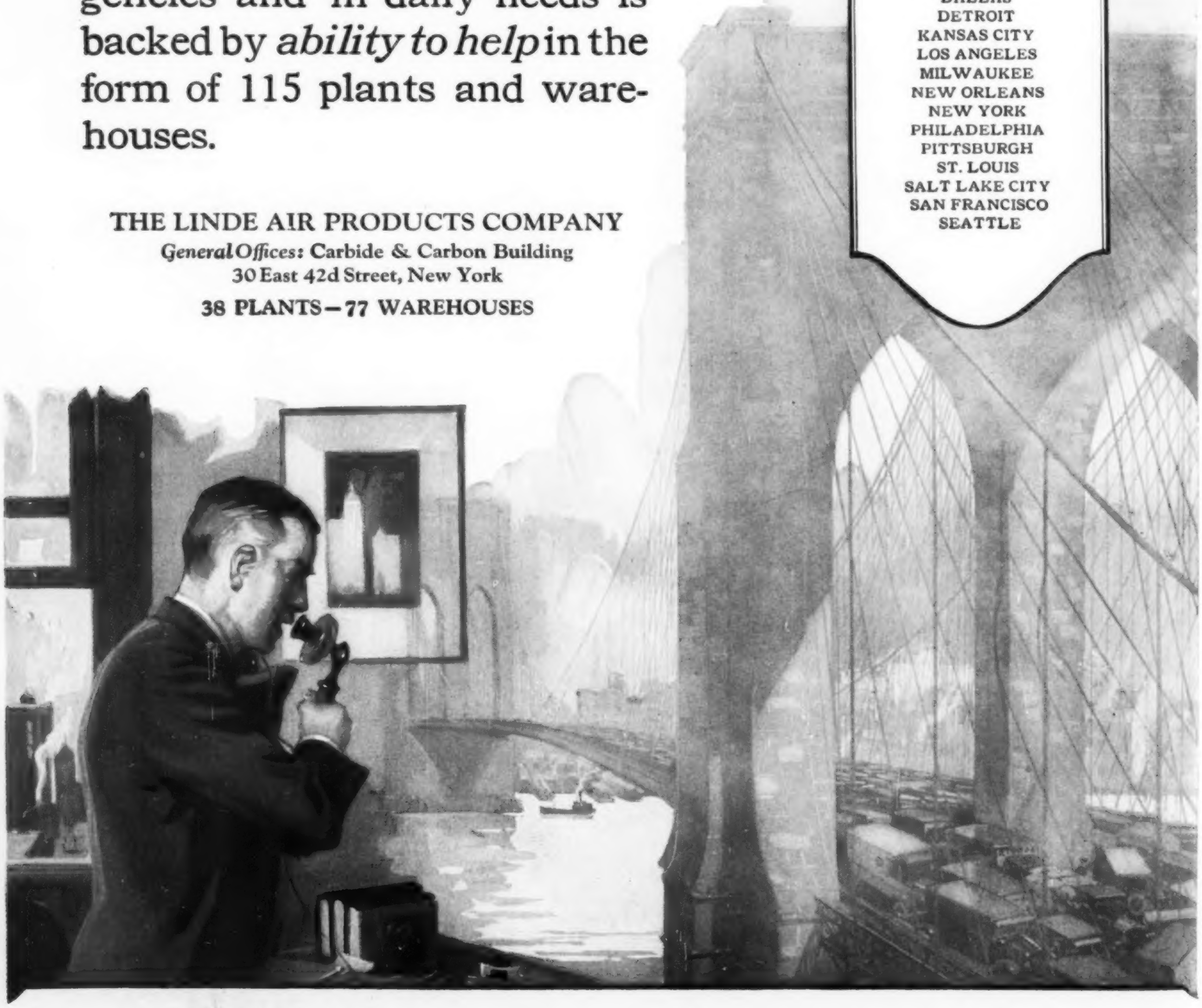

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Underwood & Underwood
H. A. Gardner

M. F. Sayre

Harris & Ewing
W. H. Rastall

B. H. Blood

D. Basch

F. O. Ellenwood

Contributors to this Issue

C. F. Hirshfeld and **Frank O. Ellenwood** are co-authors of the paper in this issue on High Pressure, Reheating, and Regenerating for Steam Power Plants. Mr. Hirshfeld was graduated from the University of California in 1902 with the degree of B.S. He was instructor and professor in Sibley College, Cornell University, 1903–1913. Since that time he has been chief of the Research Department of The Detroit Edison Company. He has also practiced miscellaneous consulting engineering since 1900. He attained the rank of lieutenant colonel in the U. S. Army during the World War.

Professor Ellenwood was graduated from the mechanical engineering department of Stanford University in 1904, and spent the next four years with C. C. Moore & Co., of San Francisco, the Tonopah Railroad Co., of Tonopah, Nev., and the American Smelting & Refining Co., San Francisco. From 1908 to 1911 he was an instructor at Stanford University. From 1911 to 1916 he was assistant professor of heat power engineering at Cornell University, and since 1916 he has been professor in that department.

* * * * *

W. H. Rastall, chief of the industrial machinery division of the Bureau of Foreign and Domestic Commerce since 1921, is the author of the paper on The Export Problem of the Machine-Tool Industry. Mr. Rastall received his M.E. degree from Cornell University in 1904. For the next seven years he acted as resident engineer for the American Trading Co. in Kobe, Japan. Upon his return to this country he became sales engineer for the Worthington Pump & Machinery Corporation. In 1917 Mr. Rastall joined the Bureau of Aircraft Production as aeronautical mechanical engineer. From 1918 to 1921 he was engaged in investigating the markets for industrial machinery in Asia.

* * * * *

B. H. Blood, whose paper discusses some possibilities and limitations on extreme accuracy in manufacturing work, is general manager of Pratt & Whitney Co., Hartford, Conn. He was graduated from Cornell University in 1889 (M.E.—E.E.), after serving an apprenticeship in the machinist's trade. Before assuming his present position in 1917 he served as master mechanic at Watervliet Arsenal, and as works superintendent with the Celluloid Co. He has given particular study to problems of high-precision measuring and manufacturing work in the machine shop.

* * * * *

H. E. Birch and **H. V. Coes** contribute an article on Coal-Storage Systems. Mr. Birch, engineering manager of the R. H. Beaumont Co., Philadelphia, Pa., was educated in the public schools of Philadelphia and in 1910 entered the employ of the D'Olier Engineering Co., of that city. At the close of that year he became connected with the R. H. Beaumont Co. Since 1914 he has had continuous charge of all designs produced by the company.

Mr. Coes, manager of the Philadelphia office of Ford, Bacon & Davis, Inc., was graduated from the Massachusetts Institute of Technology in 1906. His first connection was with the Liquid Carbonic Co., of Chicago. Later he was associated with the firm of Lockwood, Greene & Co., Boston, Mass. His next position was as vice-president and general manager of the Sentinel Manufacturing Co., New Haven, Conn., from which he resigned in 1914 to become associated with Gunn, Richards & Co., in the reorganization of munitions plants in Canada. Since 1917 Mr. Coes has been connected with Ford, Bacon & Davis.

* * * * *

D. Basch and **M. F. Sayre** present in this issue a paper on Resistance of Various Aluminum Alloys to Salt-Water Corrosion. Mr. Basch received his technical training in the University of Berlin and the Polytechnicum, Charlottenburg, Germany, being graduated as an electrical and mechanical engineer. Since 1900 he has been connected with the General Electric Co., first as electrical engineer and then as research engineer on metals and processes.

Mr. Sayre is assistant professor of applied mechanics in Union College, Schenectady, N. Y. He received his E.M. from Columbia University in 1907 and after three years of practical experience returned as an assistant, receiving an M.A. in 1911. From 1911 to 1913 Professor Sayre was construction superintendent with the Croton Magnetic Iron Mines, Brewster, N. Y. In 1914 he became an instructor in Union College, where he is now in charge of work in mechanics of materials, hydraulics, and heat engines. For the past four years he has also been engaged as consultant on research work by the General Electric Co.

* * * * *

Henry A. Gardner, who writes on Recent Observations Regarding the Corrosion, Cleaning, and Protection of Aluminum, has been Director of the Scientific Section of the Paint Manufacturers' Association of the United States for fifteen years, and is now conducting research work for this organization and the Educational Bureau of the Varnish Mfrs'. Assoc. of the United States.

* * * * *

A. W. Benoit is the author of Organization and Construction of Woolen Mills. After being graduated from the Lawrence, Mass., high school he was employed by the Pacific Mills, of Lawrence for two years. In 1903 he entered Tufts College in the department of civil engineering and was graduated with the degree of B.S. in 1907. Mr. Benoit was employed by William Wheeler, consulting engineer, of Boston, until 1909, doing both office and field work. Since then he has been in the employ of Chas. T. Main, Boston, Mass., as textile engineer.

A.S.M.E. Spring Meeting

Cleveland, Ohio, May 26–29, 1924

One of the features of the Meeting will be the presentation of a paper on The Mercury-Vapor Process by W. L. R. Emmet, consulting engineer for the General Electric Co. at Schenectady. This will be the first formal presentation of this subject that Mr. Emmet has given.

Details of the program, as they are arranged, are given in the current issues of the A.S.M.E. News.

MECHANICAL ENGINEERING

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The "Dobbin"—A Repair Shop Afloat

The Purpose of Which is to Provide Facilities Ample for Carrying Out Any Work Required on Instruments or Machinery Aboard Destroyers of the U. S. Navy

Hundreds of years before Columbus, in the days when the hardy Norsemen made their trips to Vinland in America, the mariners' encyclopedia of those days, The Book of Hlaf the Woman, strictly enjoined the captain to "mind his gear." It was not a difficult matter to do in those days of elementary navigation, as the whole gear consisted only of a few odds and ends of tools and ropes, with perhaps a barrel of pitch thrown in.

It is a far cry, however, from those days to the highly complicated and specialized machinery of the modern navy, which includes such apparently diversified products as a gyroscope compass, and naval chronometer on the one hand and huge turbines and steam generators on the other.

For a long time the U. S. Navy has felt that, should it be called upon to undertake operations abroad, especially in places remote from adequate machine-shop facilities, there might be difficulty in keeping the machinery and instruments on shipboard in shape, especially in the case of destroyers and submarines, and in quickly effecting the necessary repairs.

Such was the case, among other things, during the recent war when a number of the smaller American Navy units were operating off European shores, and the idea of the *Dobbin* and its sister ship the *Whitney* was the outcome of that experience.

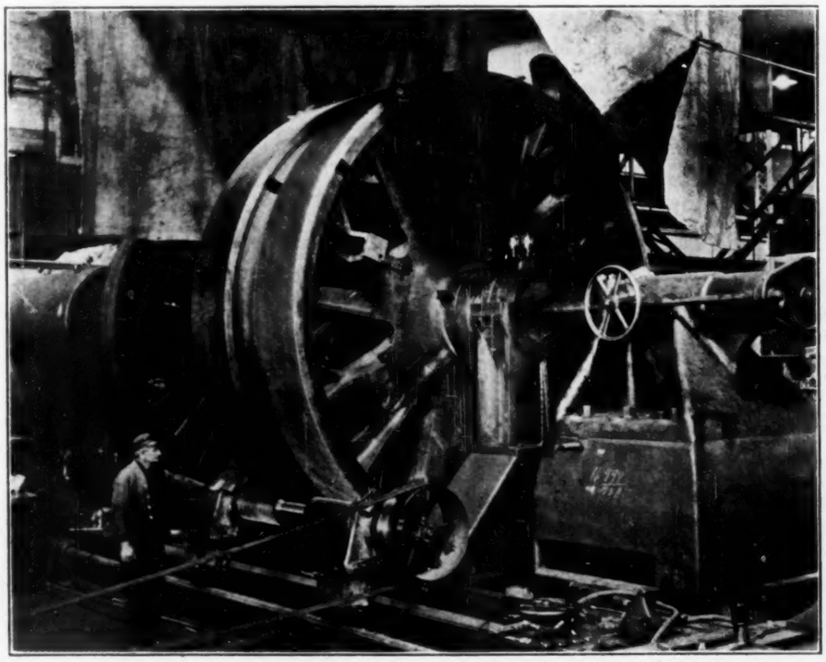

Fig. 1 Reduction Gear, U. S. S. "Dobbin"

The Purpose of a Floating Repair Shop

The purpose of a floating repair shop like the *Dobbin* is to provide facilities ample for carrying out any work that may be required on instruments and for repairing parts of machinery that are not too large to be handled by its equipment. In the American Navy all ships have a complete set of blueprints of the machinery on board, including those of every part on the ship. The majority of these ships have also a set of Van Dykes so that reproductions for the shops can be made. If a part gets broken or wears out it is a comparatively simple matter for the ship to send to the floating repair shop the information necessary to repair or replace the part, provided the necessary facilities are available on shipboard.

The *Dobbin* and her sister ships, of which only one, the *Whitney*, has been laid down, are, however, more than mere repair shops for machinery. They are mother ships for destroyer flotillas in more than one sense and represent in fact an attitude of mind toward destroyer operation entirely different from that which prevailed, say, a score of years ago. A destroyer is a comparatively small vessel carrying an amount of machinery entirely out of proportion to its size. Because of this there is extremely little room on board to devote to the comfort of human beings, and as the hero of Kipling's "Their Lawful Occasions"—a destroyer commander himself—expressed it, "they don't shave on destroyers and don't wash much." Worse than that, however, the destroyers are lacking not only in such comforts as laundry facilities but even in facilities for rendering medical help beyond merely first aid. If a man on a destroyer became sick, had a toothache, or broke an arm, all he could do was to suffer, unless accidentally the destroyer met a larger vessel, to which he could be transferred. Worse still, however, men with contagious diseases, sometimes of the most unwholesome kind, had to be kept on board, gravely endangering the remainder of the crew. The lack of such facilities as laundries may not be serious for destroyers operating in proximity to their bases, but in foreign service it becomes a really serious matter. One of the purposes of the *Dobbin* is to take care of this situation, which is apt to materially affect the efficiency of a destroyer force.

The hospital facilities of the *Dobbin* are of a very complete character, considering the limitations of space, and comprise an operating room, full dental equipment, a pharmaceutical department, a sick bay for ordinary diseases and another one for contagious diseases, a barber shop, etc.

In addition to these there are a number of facilities provided for improving living conditions on board ship, facilities which are taken for granted by men on shore, but the lack of which is seriously felt under certain conditions. The mechanical laundry has already been referred to. Another facility is the bakery, capable of supplying destroyers not only with fresh bread but even with cakes and cookies, a matter of considerable importance to young men away from shore for weeks at a time. Ice-making machines on the ship stand ready to provide the men with fresh meats and cold-storage foods, of very great value in southern climes. A small library is ready to relieve the tedium of life on board, and a recreation room is available for those of the men who can visit the ship.

In addition to this the *Dobbin* is prepared to act as a source of supplies for the destroyer flotilla, and carries everything that a destroyer may need in the way of equipment from engineer's stores down to torpedos, as well as a certain amount of fuel oil.

As a machine shop, or better, as a combination of shops, the *Dobbin* is very complete, and one cannot but marvel at the ingenuity

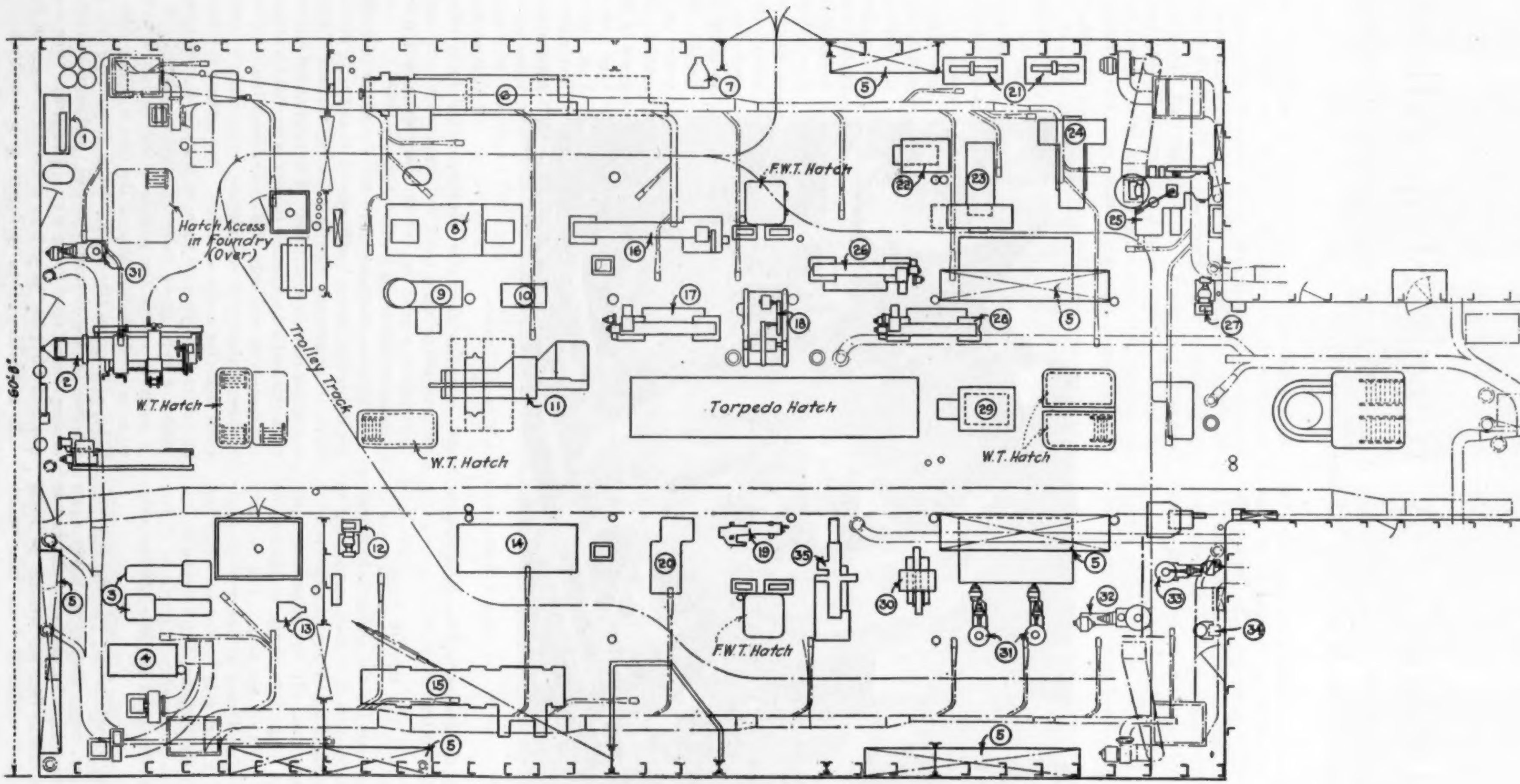

FIG. 2 MACHINE-SHOP ARRANGEMENT, U. S. S. "WHITNEY" AND "DOBBIN"

(1, Precision lathe; 2, armature-winding machine; 3, engine lathe (12 in. by 6 ft.); 4, buffing machine; 5, work bench; 6, extension gap lathe (36 in. by 60 in. by 16 ft.); 7, arbor press; 8, engine lathe (24 in. by 10 ft.); 9, 34-in. vertical boring mill; 10, centering machine; 11, space for horizontal boring mill; 12, emery wheel; 13, arbor press; 14, space for $2^1/_4$ by 24-in. flat turret lathe; 15, open-side planer (24 in. by 36 in. by 8 ft.); 16, engine lathe (20 in. by 12 ft.); 17, engine lathe (14. in. by 6 ft.); 18, torpedo-handling hoist; 19, hack saw; 20, 30-in. radial drill; 21, precision lathe (8 in. by 22 in.); 22, 6-in. metal saw; 23, $1^1/_2$-B universal milling machine; 24, 2-B universal milling machine; 25, 34-in. vertical turret lathe; 26, engine lathe (16 in. by 8 ft.); 27, emery wheel; 28, engine lathe (16 in. by 8 ft.); 29, 2-A universal grinder; 30, 16-in. crank shaper; 31, $22^1/_2$-in. upright drill press; 32, 28-in. upright drill press; 33, $22^1/_2$-in. upright drill press; 34, 16-in. sensitive drill; 35, 25-in. crank shaper.)

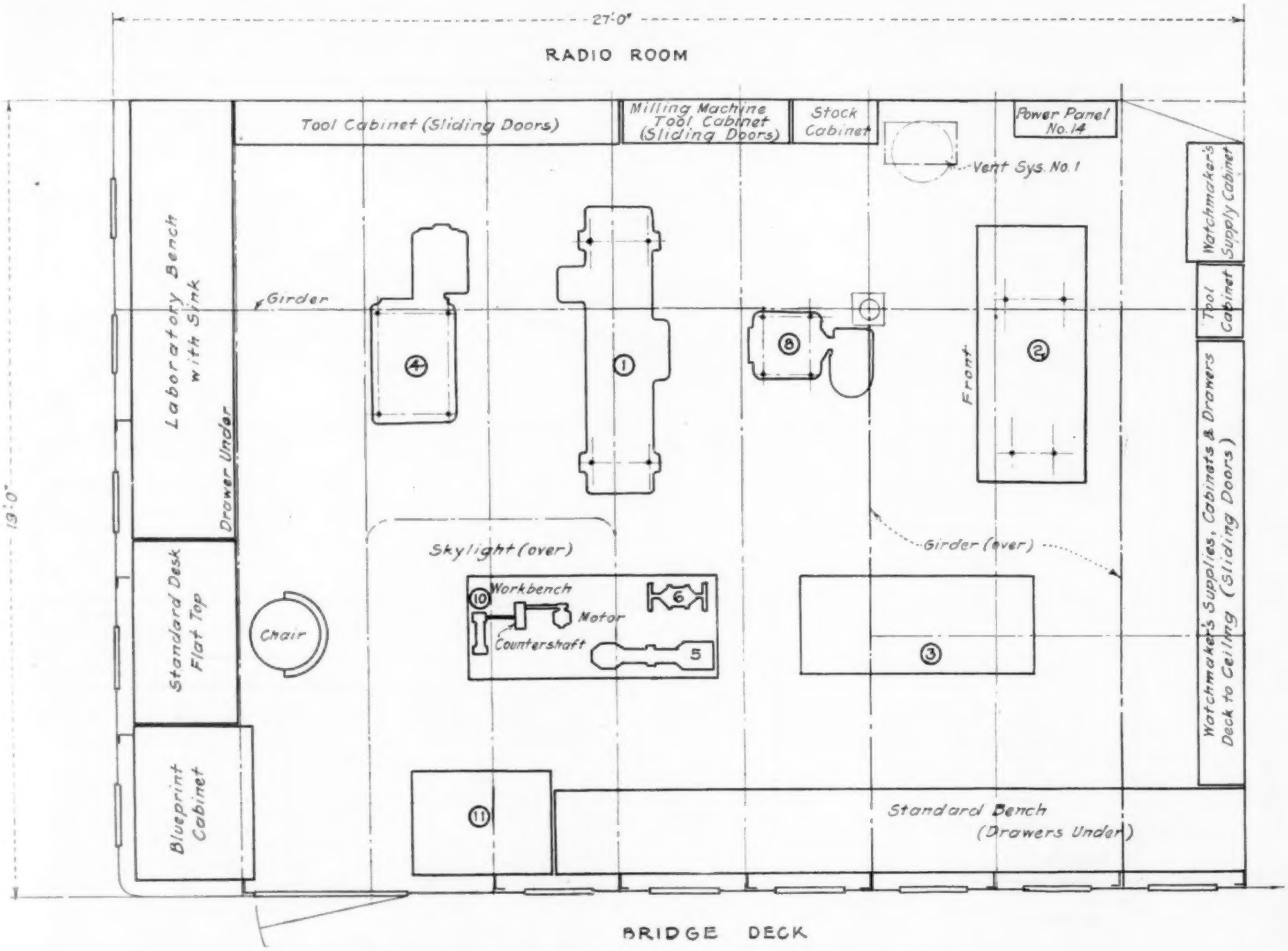

Fig. 3 Layout of Tools in Optical Shop, U. S. S. "Dobbin"

(1, Engine lathe 12 in. by 6 ft.; 2, toolmaker's lathe, 10 in. by 3 ft. 6 in. centers; 3, precision bench lathe with cabinet; 4, milling machine; 5, sensitive bench drill; 6, bench grinder; 8, wet and dry grinder; 10, watchmaker's lathe; 11, bench milling machine. The equipment also comprises a Dumar portable grinder and a portable buffing motor.)

displayed in installing such an assortment of varied and at times quite heavy material in the space available, especially in view of certain limitations which have to be taken into consideration.

The Navy fully realizes that the efficiency of its vessels depends on their ability to maintain their equipment in good order under the wear and tear of war conditions, especially in foreign service. The principle underlying the entire design of the *Dobbin* and her sister ship is expressed in the part of the specification referring to the tools, which reads as follows: "All tools will be of the best design, material, quality and workmanship; will have the latest improvements and all necessary attachments and wrenches." Nothing but the best is good enough for the Navy, and nothing but the best should be used under conditions where the safety of the men and perhaps the country may depend on the efficiency of the Navy units.

The Power Plant of the "Dobbin"

The *Dobbin* is equipped with cross-compound-type turbines. One propeller shaft is driven through gearing by one high-pressure and one low-pressure turbine. In the casing of each turbine there is fitted an astern turbine capable of developing 50 per cent of the full power ahead. The gage boiler pressure is 215 lb., the steam pressure (gage) at the high-pressure turbine 200 lb., and the r.p.m. 105. Under these conditions the plant will deliver to the propeller 7000 shaft hp., which will give the ship a speed of 16 knots. In the engine room are installed two 200-kw. and one 100-kw. turbo-generators which will operate at 125 volts d.c.

Steam is supplied the turbines by two water-tube boilers, express type, equipped only for fuel oil and having a total heating surface of 14,400 sq. ft.

The line shaft, of forged steel, is in three sections, and is supported by six self-oiled spring bearings. The diameter of the shaft is $16^{5}/_{8}$ in.; the coupling disks are $30^{1}/_{2}$ in. in diameter and $3^{1}/_{2}$ in. thick. The diameter of the propeller shaft in the stern tube is $18^{3}/_{8}$ in.; its diameter forward is $17^{1}/_{2}$ in.

The difficult problem in the design of such a ship as the *Dobbin* floating workshop is to accommodate the equipment necessary in the comparatively limited space of a ship. In the present instance the major divisions of the ship comprise a hospital, a foundry and coppersmith shop, an optical shop—in which will be located watch-repair equipment; a pattern shop; blacksmith, shipfitter and carpenter shops; torpedo-repair, shoe-repair, and machine shops.

Ventilation is taken care of by a pressure system, the supply of fresh air being drawn from the upper deck and discharged into the rooms. In cold weather the air is discharged through steam-heated coils. Means for humidifying the warmed air are provided.

The lighting is accomplished by incandescent lights and a generous distribution of sockets into which the portable lights can be inserted.

The Shops and Their Equipment

In laying out the machine shop the difficulty encountered was the fact that some of the floor space had to be left free, or at least quickly available. This refers practically to the hatches indicated on Fig. 2 and specially to the large torpedo hatch right in the middle of the floor.

The conditions were such as to make the use of an overhead crane unsuitable and therefore an overhead trolley track was provided. The layout of the machine shop is shown in Fig. 2; to the left of this are the gyro-repair shop and electrical repair

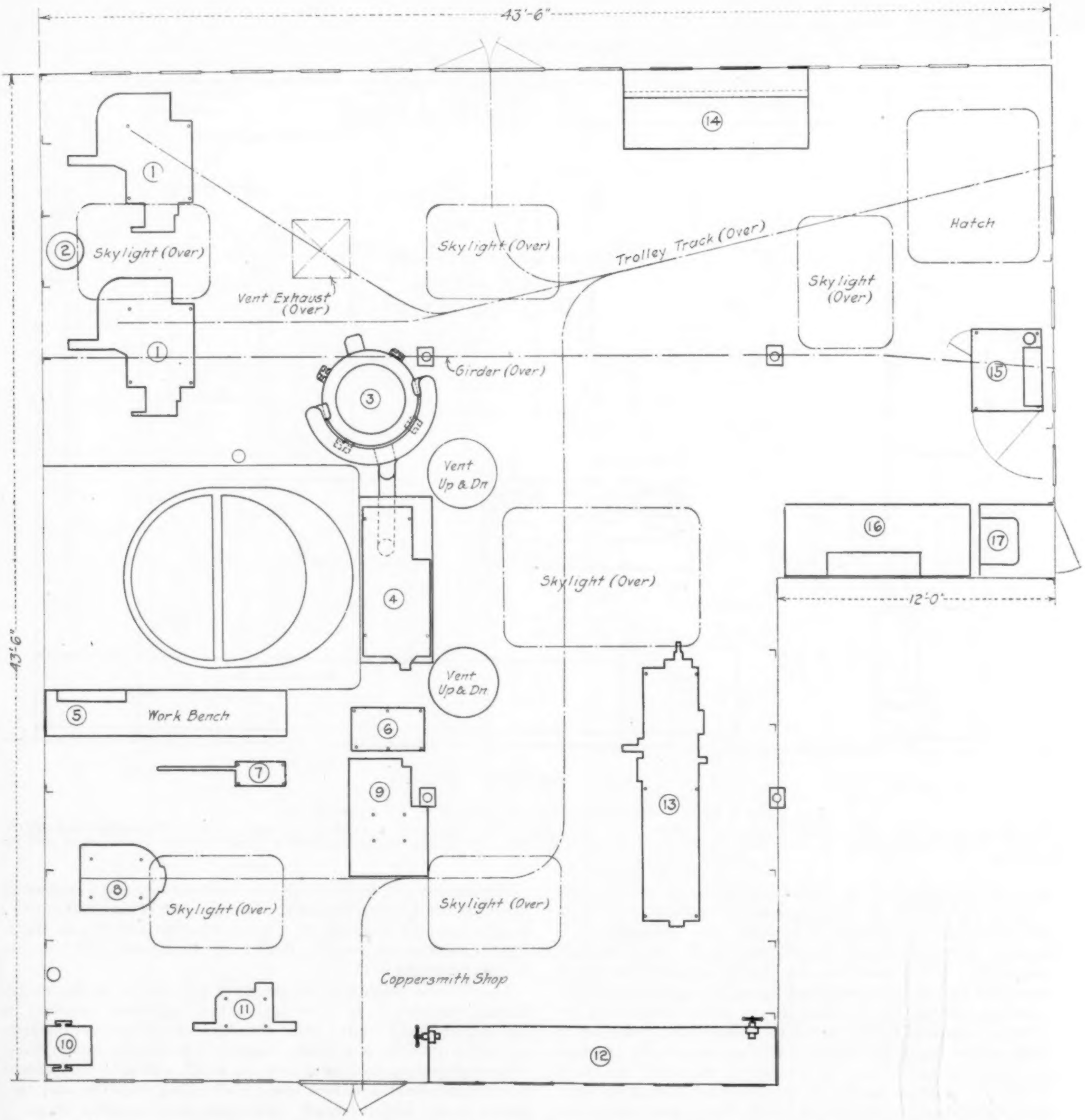

FIG. 4 LAYOUT OF MACHINERY IN FOUNDRY AND COPPERSMITH SHOP OF U. S. S. "DOBBIN"

(1, Marine tilting crucible furnaces; 2, 50-gal. fuel-oil tank; 3, $1^1/_2$-ton cupola; 4, cupola blower; 5, work bench; 6, motor-driven hydraulic pump; 7, hand shear; 8, coppersmith's fuel-oil furnace; 9, 35-ton hydraulic pipe-bending machine; 10, portable oxy-acetylene welding outfit; 11, hand pipe-bending machine; 12, work bench with vises; 13, tinsmith rolls; 14, molder's bin and pattern shelf; 15, core oven; 16, coremaker's bench; 17, slop sink.)

shop, and to the right are the ship's office and drafting room, the latter being equipped with complete blueprinting facilities.

As regards the machine shop, attention may be called to the great care which has been taken to make operations safe. All machines are equipped with safety devices and guards. The lathes have a complete set of change gears for cutting U. S. Navy standard screw threads, including $11^1/_2$ threads per inch. The majority of the machine tools are driven by independent semi-enclosed variable-speed electric motors. The lathes are provided with reversible drum-type controllers attached to the carriage. All motors are direct-connected without the intervention of belting.

The machine shop is divided into three main sections, the gyro repair shop containing some small tools and test panels, as well as other electric equipment for gyro-compass repair and testing. The electrical shop has such equipment as a coil-winding machine, taping machine, paper cutter, spreader and armature-coil winder, test panels, and two bake ovens, in addition to small tools, including precision lathes, and a machine shop proper with a remarkably complete equipment considering the space available. This equipment comprises such tools as a 36-in. by 60-in. by 16-ft. extension gap lathe, several regular engine lathes, an open-side planer, a 34-in. vertical turret lathe, a 34-in. vertical boring mill, a 72-in. horizontal boring, drilling, and milling machine, a $2^1/_2$-in. $\times$ 24-in. flat turret lathe, drill presses, milling machines, tool and universal grinders, compressed air, oxy-acetylene outfit, etc., and a blueprinting machine with washer and drier.

The layout of the optical shop, together with the list of tools, as shown in Fig. 3, is an example of what can be accomplished in a

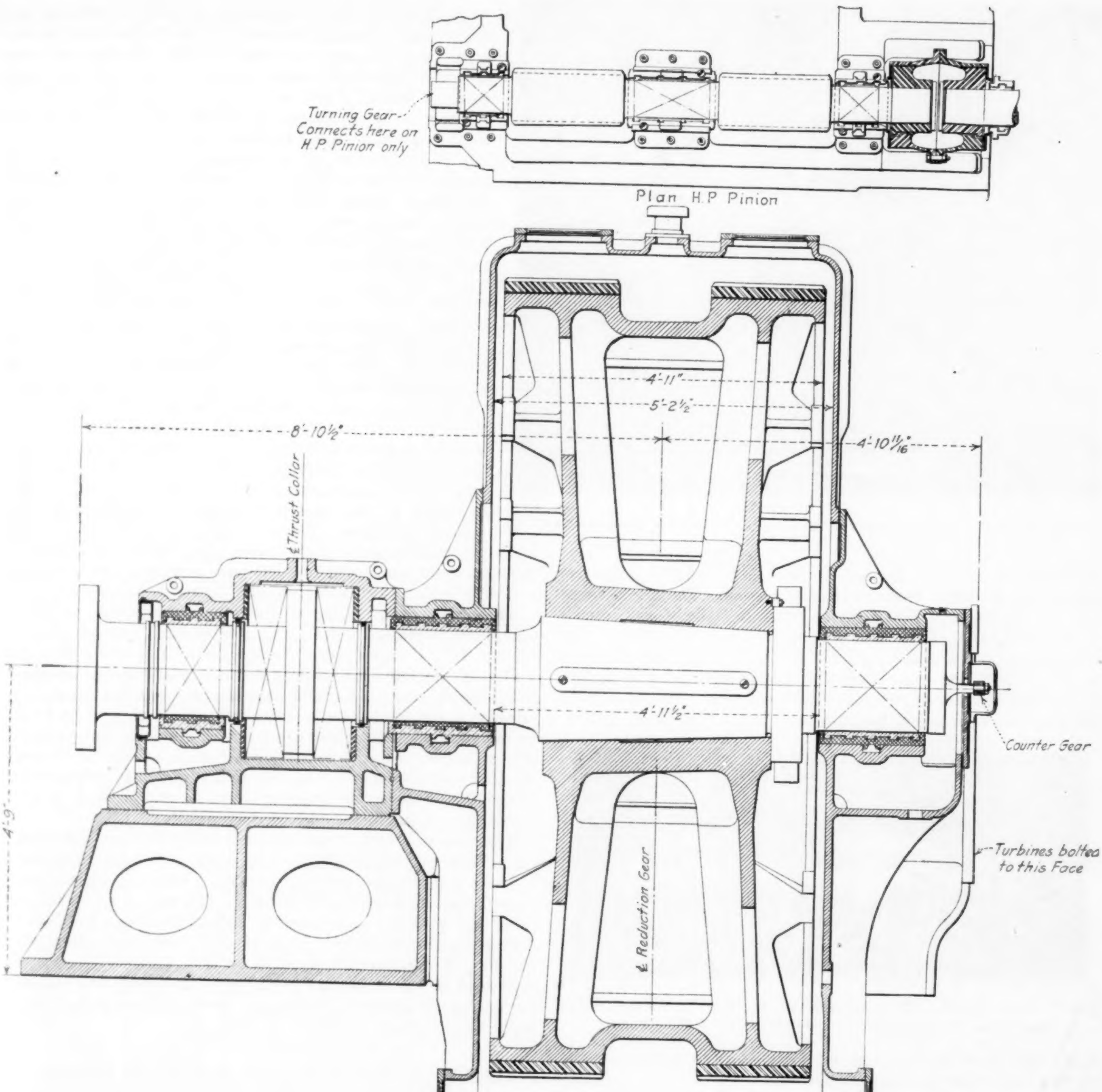

Fig. 5 Arrangement of Main Reduction Gear and Thrust Bearing, U. S. S. "Whitney" and "Dobbin"

limited floor space when both care and good judgment are used.

The foundry, shown in Fig. 4, is of interest as being probably the largest foundry afloat. Its equipment comprises, among other things, two marine tilting crucible furnaces for melting non-ferrous metals, a $1^1/_2$-ton cupola, a 35-ton hydraulic pipe-bending machine with a motor-driven hydraulic pump, a smaller hand pipe-bending machine, a coppersmith fuel-oil furnace, and a considerable amount of smaller equipment. The foundry is also equipped with an overhead trolley track.

The Reduction Gear

An interesting feature of the *Dobbin* is its immense reduction gear, one of the largest in existence. This gear, shown in Figs. 1 and 5, was built at the Philadelphia Navy Yard from designs supplied by the Parsons Marine Steam Turbine Co., and developed by the Yard for manufacturing purposes. The fact that the Navy Yard, without any previous experience in the manufacture of this type of huge gears, has been able to carry through the job to a successful conclusion, speaks well for the ability of its personnel to handle difficult mechanical problems. The gear has a pitch-circle diameter of 146 in. and 679 teeth of helical type, the face being divided into two parts, each 21 in. wide. With this big gear there meshes a pinion 9.903 in. in diameter with 46 teeth, the pinion revolving at full speed at 1550 r.p.m. and driving the gear at 105 r.p.m. The gear consists of a cast-iron hub and spider shape over which are shrunk two forged steel rings. Each pinion is cut from a nickel-steel forging. In order to relieve the casting stresses in the hub and spider frame, the latter on the outside circle where the steel rings are shrunk on is not cast as a complete ring but has eight slots in the periphery (see Fig. 1), the purpose of which is to provide

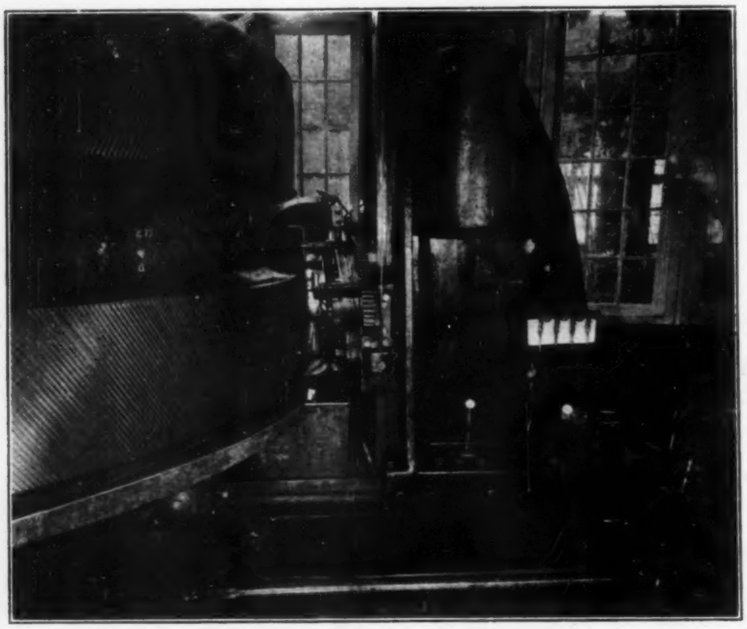

Fig. 6 Cutting the Teeth of the Huge Reduction Gear of the U. S. S. "Dobbin"

for lateral expansion of the cast-iron members and thus somewhat reduce the tendency toward radial expansion. The frame cover and bearing boxes of the reduction gear are made of cast iron.

The lubrication of the gear teeth is effected by spray nozzles attached to the oil-supply manifold. These nozzles are arranged to deliver oil at the point where the driving teeth enter in engagement when the gear is running ahead or astern. The oil used in the gear case is arranged to drain back to the turbine oil system.

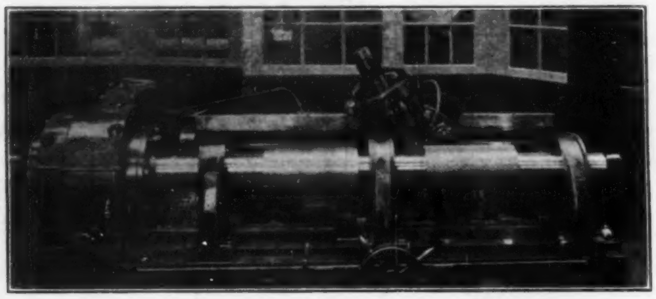

Fig. 7 Gear-Cutting Machine for Pinions, with Booth for Maintaining Even Temperature Shown in the Background

Inspection handholes are provided in the gear casing so that the oil trough can be readily cleaned out.

The gear cutting on such an immense ring (146 in. in diameter) was no easy proposition and required the application of some rather unusual methods. The procedure employed is as follows:

After the steel rings have been shrunk on, the center hole is bored and the wheel assembled on its shaft. The assembled unit is then placed in a lathe, the gear blank machined to designed dimensions and the inner faces of the checks *F* machined concentrically with it. Thereupon the blank is mounted into the position shown in Fig. 1 and the outside face of the steel rings turned to size. This is the easiest part of the job. In the cutting of the teeth, which is the really difficult problem, the gear is placed horizontally (Fig. 6) on the table of the gear-cutting machine (Parsons Marine Steam Turbine Co.). On this table there are radial moving stops, the position of which is made to correspond to the circle to which the inner faces of the checks *F*, Fig. 1, have been cut, so that once the blank is placed on the table there is no question as to its being concentric with the axis of rotation. This being done, one may proceed to the tooth-cutting operation, which is to all practical purposes hobbing. The spindle of the hobbing cutter and the table on which the gear is mounted both rotate simultaneously.

Essentially the cutting of the immense gear for the *Dobbin* would be no different from the cutting of gears of ordinary and much smaller sizes, if it were not for the fact that because of its large diameter—in excess of 12 ft.—the slightest variation of temperature produces a change of size sufficiently large to cause trouble if not taken care of. In other words, in addition to a machine-shop problem there was something in the nature of an egg-incubator problem presented, as the gear had to be kept at substantially the same temperature from beginning to end of the operation. To accomplish this the entire cutting was done in an enclosed room where electric heaters were used to maintain the correct uniform temperature. Furthermore, once the cut was started it had to be carried to the end without stopping, otherwise there would be several sources of error that might result in a defective tooth. The cutting of the gear was therefore a day-and-night job, and it was necessary to make certain that there would be no stoppage of the work under any conditions whatsoever. The shops at the Philadelphia Navy Yard are supplied with direct current from the main generating station. Conditions of work at the Yard, however, are such that at times for short periods power can be cut off from the shops. In order to insure that this would not entail a stoppage of the work on the gear, storage batteries were installed sufficient to carry the load on the gear-cutter motor for 8 hr., or much in excess of the longest stoppage to be expected under normal conditions. The use of the storage batteries, it may be remarked, did not involve the expense of purchasing them, as there are always a considerable number of such batteries available in the Yard, and they have to be kept charged anyway.

The cutting feed employed was only 0.012 in. per revolution, and as one revolution took 13 min., it is obvious that in an afternoon of, say, 4 hr. a depth of cut of only about $^1/_4$ in. could be taken.

One of the interesting features of the gear-cutting machine is the creeping gear. The table carrying the gear is located eccentrically to and meshes on its interior surface with a worm located at the end opposite to that where the ring meshes with the table. The arrangement is such that after each cut is completed the cutter does not start at the same place where it left off but skips four teeth. While this arrangement involves certain complications, it is believed that it produces much cleaner results.

After one side of the gear has been completely cut the blank is turned over and the other half is cut in the same manner as before.

There is now under way another gear a couple of inches smaller than the one intended for the *Dobbin*. This can be cut on the same table and with the same hobbing cutters that were used on the *Dobbin* gear, but of course the gearing of the table and cutter spindle will have to be changed.

Several ingenious devices have been developed and employed for testing the accuracy of the gear teeth. These cannot be described here owing to lack of space.

The daily papers report that four boats for the Roosevelt Line have been ordered abroad and that these boats will all be of the motor-driven type. While there is a proposition in Congress to create a fund out of which loans could be given to American companies for converting steamers, including the Hog Island type, to motor drive, no formal action on this legislation has so far been taken.

These developments are of importance in view of the continuing competition for ocean freights. As a sample may be mentioned the low ocean freight rates recently obtained, according to the *Iron Trade Review*, March 13, 1924, on shipments of steel and steel products from Europe to America.

On an inquiry for 5000 tons of billets from San Francisco, Scotch steel-makers were recently quoted about 1£ ($4.30) a ton. Pig iron is still handled from Antwerp to San Francisco at 17 s. 6 d. ($3.75) per gross ton in lots of 500 tons or more, the rate from Hamburg, Middlesborough, or Glasgow being about 1 s. higher. Finished steel from Europe to the Pacific coast remains at around 1 £ 10 s. ($6.45) per gross ton.

A vessel has recently been chartered to carry iron ore from Benisaf to Philadelphia at 6 s. 9 d. ($1.45) per ton, this rate being actually about 1 s. less than the charge to the United Kingdom or Germany.

High Pressure, Reheating, and Regenerating for Steam Power Plants

By C. F. Hirshfeld,[1] Detroit, Mich. and F. O. Ellenwood,[2] Ithaca, N. Y.

In this paper the authors discuss the relative thermal and investment costs involved in a modern turbo-generator station, as determined by a consideration of steam pressures from 200 to 1200 lb. per sq. in., steam temperatures of 700 and 800 deg. fahr., and six different cycles of operation in which reheating and regenerating are involved in various degrees. Particulars regarding the study are summarized in the two paragraphs immediately following.

This paper is a study of the relative thermal and investment costs involved in a modern turbo-generator central station, as determined by a consideration of steam pressures from 200 to 1200 lb. per sq. in., steam temperatures of 700 and 800 deg. fahr. and six different cycles in which reheating and regenerating are involved in various degrees.

The work naturally divides itself into two parts, the first of which deals with the information that may be gained from a study of the ideal cycles, the second with the probable fuel economies and operating characteristics that may be expected from real plants operating on the several cycles and at various pressures. The second portion of the paper also includes the relative investment costs which have been worked out in so far as they are affected by the various cycles and steam pressures.

I—IDEAL STEAM-POWER-PLANT CYCLES

An actual steam plant, unfortunately, cannot be operated under ideal conditions, but nevertheless the study of ideal cycles is of particular importance to engineers at the present time because they are working in the midst of many new developments relating to very high pressures and various schemes for reducing the exhaust losses. The exhaust loss in a real plant is larger than all the others combined, so that the best way of utilizing some of this exhaust heat, other than by industrial heating—which is sometimes feasible—becomes a problem of increasing importance as higher fuel prices are encountered.

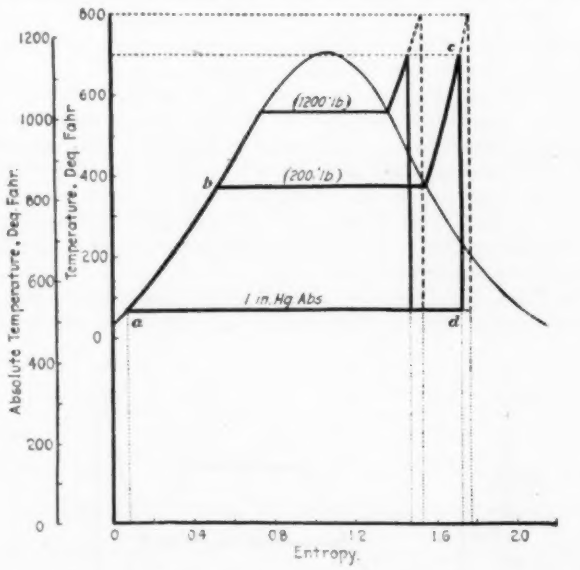

Fig. 1 Cycle A (Rankine)

(For throttle pressures of 1200 and 200 lb. per sq. in. abs., temperatures of 700 and 800 deg. fahr., and exhaust pressure of 1 in. Hg abs.)

In this study it is assumed that at the present time the upper limit of the temperature of steam that can be used successfully in steam power plants is from 700 to 725 deg. fahr. The ideal-cycle diagrams have therefore been drawn with solid lines for a temperature of 700 deg. and with dotted lines for a temperature of 800 deg., a value which may possibly prove feasible in the next few years. The ideal-cycle calculations have been made for both temperatures, and the corresponding efficiency curves have been drawn solid and dotted, respectively.

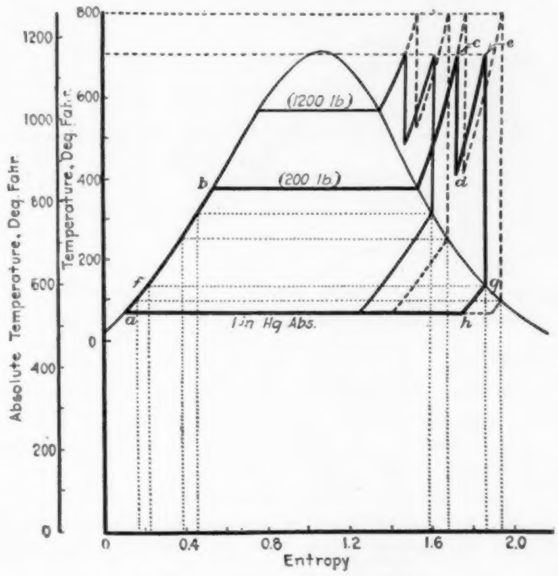

Fig. 2 Cycle B (Reheating)

(For throttle pressures of 1200 and 200 lb. per sq. in. abs., temperatures of 700 and 800 deg. fahr., and exhaust pressure of 1 in. Hg abs.)

Names and Diagrams of the Cycles

The different cycles have been designated respectively by the first six letters of the alphabet. The names chosen are intended to be characteristic of the most unusual parts of the cycle, or in other words to identify the cycle by a name which indicates the unusual processes involved.

The Rankine Cycle (A), Fig. 4, is made up of the processes indicated in Fig. 1. In this cycle the steam is formed at constant pressure and is then considered to pass without any loss by throttling or radiation to the turbine, in which the adiabatic expansion, *cd*, takes place until exhaust pressure is reached as indicated by the state *d*. Condensation of the exhaust steam then takes place at constant pressure as shown by the line *da*. This cycle has much to recommend it from the standpoint of simplicity and is the one in most common use today. It does not, however, have as great possibilities regarding thermal economy as some of the others.

The Reheating Cycle (B) is composed of the processes shown in Fig. 2. The steam expands adiabatically from *c* to *d* and then is reheated at constant pressure from *d* to *e*, after which a second adiabatic expansion takes place from *e* to *f*. The rest of the cycle is the same as cycle A. This reheating implies that the steam is carried back to the boiler plant to pass through a suitable reheater and is then returned to the turbine in which the expansion is completed, or else that there has been provided near the turbine a suitable separately fired reheating apparatus so that the steam does not have to be carried back to the boiler room. Both of these schemes involve certain complications and possibly difficulties in a real plant.

The Cycle with Isothermal Superheating (C) consists of the proc-

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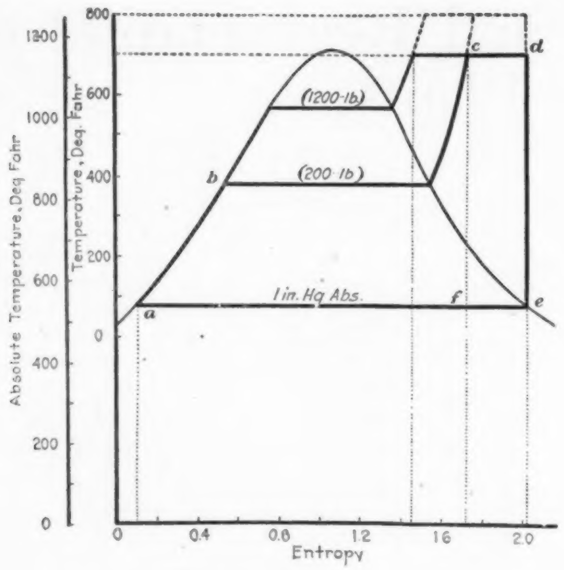

FIG. 3 CYCLE C (ISOTHERMAL-SUPERHEATING)

(For throttle pressures of 1200 and 200 lb. per sq. in. abs., temperatures of 700 and 800 deg. fahr., and exhaust pressure of 1 in. Hg abs.)

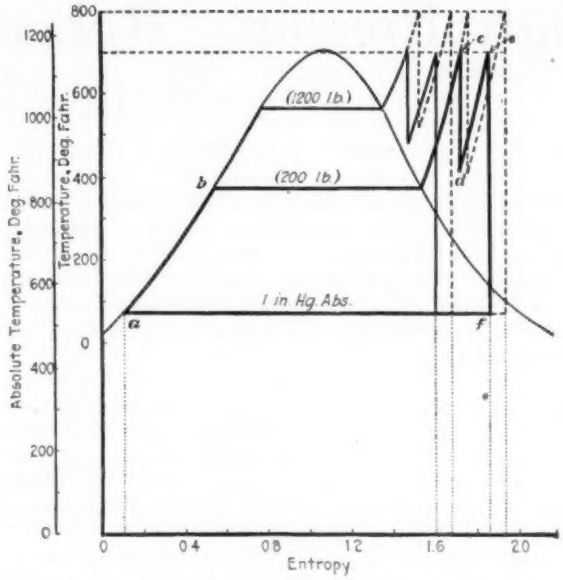

FIG. 5 CYCLE E (REHEATING-REGENERATING)

(For throttle pressures of 1200 and 200 lb. per sq. in. abs., temperatures of 700 and 800 deg. fahr., and exhaust pressure of 1 in. Hg abs.)

esses shown in Fig. 3. This name is used because the cycle involves an isothermal expansion of superheated steam as indicated by the line *cd*. It is not claimed that this process is likely to be approached even approximately in any real turbine. The study of this cycle, however, does offer one very great advantage, in that it shows a maximum which might be approached by using an infinitely large number of constant-pressure reheating devices as explained for cycle B.

The Regenerative Cycle (D), Fig. 4, is called "regenerative" because steam is bled from the turbine at a number of stages to feedwater heaters, and the heat which is thus recovered is returned to the boiler.

In the ideal cycle an infinitely large number of bleeder heaters are assumed to be used, so that if superheated steam is not bled, the line *de* is drawn parallel to the liquid line *fa*. If there had been no bleeding, the adiabatic expansion would have continued to the state *e'*. On the other hand, with bleeding, successive portions of the steam are withdrawn from the turbine and condensed, heating the feedwater, while the remainder proceeds through the turbine, continuing the isentropic expansion.

If at each temperature the portion in the turbine and the portion which has been bled and condensed be considered to be mixed together, the resultant state is that shown on a curve drawn parallel to the liquid line. In other words, the curve *de* is drawn for the entire weight of steam considered in the cycle and does not represent the state of only that portion of the steam continuing through the turbine. By drawing the diagram to represent all of the steam considered, the area *abcde* represents the energy available from this amount of steam and the equations for the cycle efficiency may be developed readily. In case superheated steam should be bled the process cannot be shown in the superheated field by drawing a line parallel to the liquid line. It is particularly instructive to observe from Fig. 4 how the temperature of the feedwater rises in this cycle as we go to high pressures.

The Reheating-Regenerative Cycle (E) is outlined in Fig. 5. It is called "reheating-regenerative," for the reason that the steam is reheated as in the case of cycle B, and then the regenerative principle is also applied as discussed for cycle D. Therefore the area *abcdegh* represents the available energy in B.t.u. per pound of throttle steam. This cycle implies considerable complication, but its possible advantages may apparently justify the building of a plant to operate with this ideal.

The Isothermal-Regenerative Cycle (F) is made up of the processes shown in Fig. 6. This cycle can hardly be called an im-

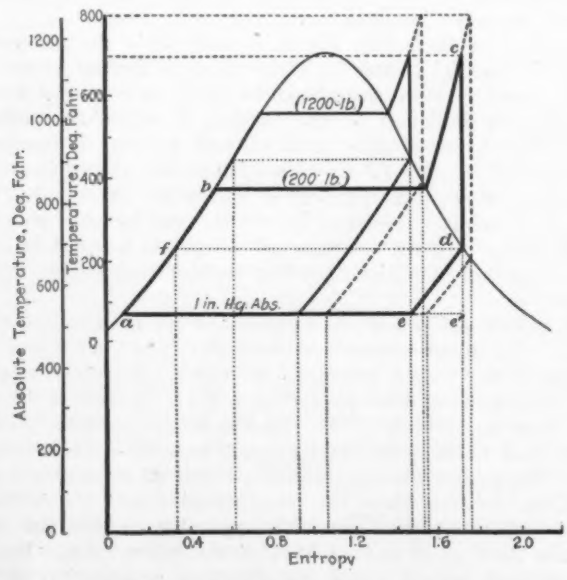

FIG. 4 CYCLE D (REGENERATIVE)

(For throttle pressures of 1200 and 200 lb. per sq. in. abs., temperatures of 700 and 800 deg. fahr., and exhaust pressure of 1 in. Hg abs.)

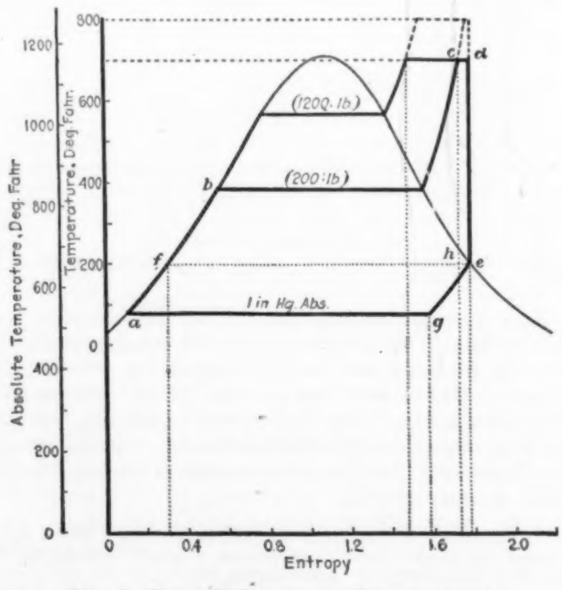

FIG. 6 CYCLE F (ISOTHERMAL-REGENERATIVE)

(For throttle pressures of 1200 and 200 lb. per sq. in. abs., temperatures of 700 and 800 deg. fahr., and exhaust pressure of 1 in. Hg abs.)

portant one except in so far as it indicates the limiting possibilities of cycle E with an infinitely large number of reheaters, so that the isothermal expansion in the superheated region is approached as shown by the curve *cd*. The regenerative portion of this cycle is exactly similar to that described for the two previous cycles, except that the saturation temperature at which the bleeding begins is determined by the amount of isothermal expansion permitted in the turbine. In other words, the length of the line *cd* determines the temperature at *e* and consequently at *f*.

Efficiencies of Ideal Cycles

The efficiency of any ideal cycle is the ratio of the available energy, or the energy convertible into work, to the heat supplied during the entire cycle. In order to save space the cycle efficiencies will each be expressed in general terms, using the following notation:

Let H = specific total heat of the steam in B.t.u. per lb. for any state indicated by the subscript
q = specific total heat of the liquid in B.t.u. per lb. for any state indicated by the subscript
T = absolute temperature in deg. fahr. for any state indicated by the subscript
t = ordinary temperature in deg. fahr. for any state indicated by the subscript
p = absolute pressure in lb. per sq. in. for any state indicated by the subscript
V = specific volume in cu. ft. per lb. for any state indicated by the subscript

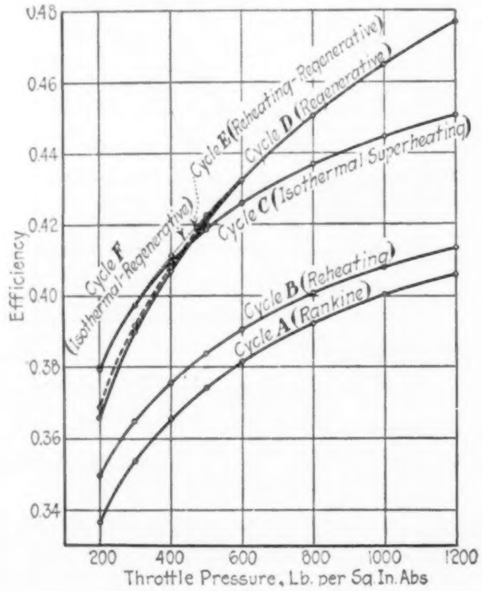

FIG. 7 COMPARATIVE MAXIMUM EFFICIENCIES OF CYCLES A, B, C, D, E, AND F

(Throttle temperature of 700 deg. fahr. and exhaust pressure of 1 in. Hg abs.)

ϕ = specific entropy for any state indicated by the subscript
F = feed-pump work of the ideal cycle, in B.t.u. per lb. of water.

With this notation, and neglecting the feed-pump work—which is considered later—we then have:

For the *Rankine Cycle* (A) as shown by Fig. 1,

$$\text{Efficiency} = \frac{H_c - H_d}{H_c - q_a}$$

For the *Reheating Cycle* (B) as shown by Fig. 2,

$$\text{Efficiency} = \frac{H_c - H_d + H_e - H_f}{H_c - H_d + H_e - q_a}$$

For the *Cycle with Isothermal Superheating* (C) as shown by Fig. 3,

$$\text{Efficiency} = \frac{H_c - H_f + (t_d - t_e)(\phi_d - \phi_c)}{H_c - q_a + T_d(\phi_d - \phi_c)}$$

For the *Regenerative Cycle* (D) as shown by Fig. 4,

$$\text{Efficiency} = \frac{H_c - q_f - T_e(\phi_d - \phi_f)}{H_c - q_f}$$

For the *Reheating-Regenerative Cycle* (E) as shown by Fig. 5,

$$\text{Efficiency} = \frac{H_c - H_d + H_e - H_g + (t_g - t_h)(\phi_g - \phi_f)}{H_c - q_f + H_e - H_d}$$

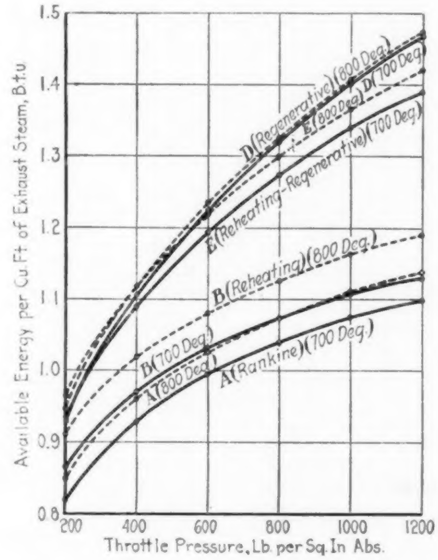

FIG. 8 AVAILABLE ENERGY PER CUBIC FOOT OF EXHAUST STEAM

(Throttle temperatures indicated on curves. Exhaust pressure, 1 in. Hg abs.)

For the *Regenerative Cycle with Isothermal Superheating* (F) as shown by Fig. 6,

$$\text{Efficiency} = \frac{H_c - H_h + (t_d - t_e)(\phi_d - \phi_c) + (t_f - t_g)(\phi_e - \phi_f)}{H_c - q_f + T_c(\phi_d - \phi_c)}$$

In calculating the efficiencies of ideal cycles, the work required to pump the water into the boiler is usually neglected. However, since this item evidently increases in importance with the pressure, it has been computed for the range of pressures considered in this paper, in order to give an accurate conception of its magnitude. It has been found that the correction is practically negligible.

Comparative Efficiency Curves

In Fig. 7 are given the efficiencies of the six cycles arranged so that they may be compared for a throttle temperature of 700 deg. fahr. and various throttle pressures from 200 to 1200 lb. per sq. in. Clearly, cycle D is the one which deserves first place, especially for the higher pressures, as far as efficiencies on the ideal basis are concerned.

In addition to the efficiency, one other value which is important to engineers and which may be calculated for the ideal cycles is the amount of energy available for work in the ideal turbine per unit volume of the steam at exhaust. This ratio is important because it is a partial measure of the relative sizes and costs of the turbines required to give the same power when operating on the different cycles. The superiority of the regenerative cycle in this regard also, is shown by Fig. 8.

Conclusions

For any cycle herein studied it is clear that there is a marked increase in efficiency and in energy available per unit volume of exhaust steam, due to increasing the throttle pressure, throughout the range considered. This increase in efficiency with the pressure is less marked in the simple Rankine cycle than in the ones with more complicated apparatus.

Changing the throttle temperature from 700 to 800 deg. fahr.

causes a very marked increase in the efficiency of all cycles herein studied except those using the regenerative principle, which are improved but very little by this increased temperature.

From the consideration of the ideal cycles alone it appears that the Rankine cycle, which is the one requiring the least apparatus, is the least efficient throughout the entire range of pressures, and yields the least energy per unit volume of exhaust steam. At the top of the list, throughout the upper portion of the pressure range considered, and very close to the top in the lower portion stands the regenerative cycle both as to efficiency and available energy per unit volume of exhaust steam. The extra apparatus which must be used in order to follow the regenerative cycle in-

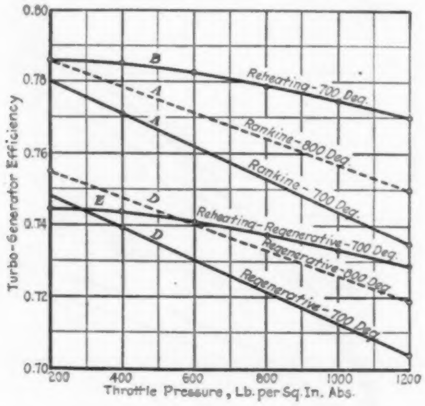

Fig. 9 Probable Turbo-Generator Efficiencies Referred to the Four Ideal Cycles, A, B, D, and E
(For 30,000-kw. units and exhaust pressure of 1 in. Hg abs.)

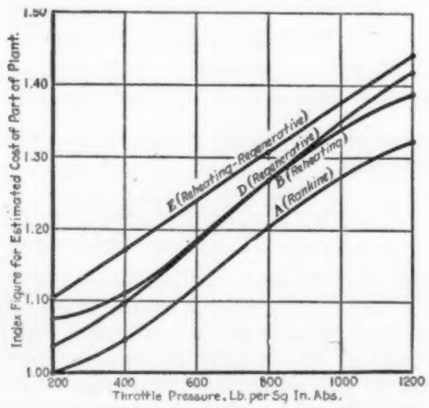

Fig. 10 Estimated Relative Costs of Central-Station Apparatus Affected by Steam Pressure and Cycle

stead of the Rankine would seem to be simple enough to justify the extra expense in many cases.

II—PROBABLE RESULTS FROM REAL PLANTS

Method of Estimating Plant Performance

Performance figures for a plant which has not been built may be obtained by modifying the results calculated for the ideal cycle on which the plant is intended to operate. The ideal-cycle output per unit mass of steam, multiplied by the turbo-generator efficiency referred to that particular cycle, gives the corresponding gross generator output. With the gross generator output per unit mass of steam the flow of steam necessary to produce any gross power output is ascertained. From this gross output must be subtracted the power required by all of the plant auxiliaries which, for the convenience of this study, were assumed to be electrically driven. This power may be estimated rather closely for the plant load and boiler rating which are considered proper for a study of this kind. Any steam required for steam-driven auxiliaries, losses, etc., could be estimated per pound of steam to the main units and thus the total steam per unit of net plant output determined, in case it should be desired to use steam-driven auxiliaries. The heat required to generate the necessary steam depends upon the boiler-room efficiency, which may be assumed to be the same for all cases in a comparative study of the type here under consideration, the extent of the heating surface being adjusted to give the efficiency assumed.

Probable Turbo-Generator Efficiencies

The efficiencies to be expected from turbo-generators of 30,000 kw. capacity when operating on the cycles under consideration with different pressures and temperatures have been calculated as well as possible, and the results are shown in Fig. 9.

The well-established curve for use with the Rankine cycle was extended to the higher pressures by allowing for the ill effect of the extra moisture encountered as the pressure increases. For curve B, or the one to be used with the reheating cycle, the values were established in the following manner: Neglecting the throttling effect through the reheater and its piping, the extra superheat from the reheater was estimated to increase the efficiency of the

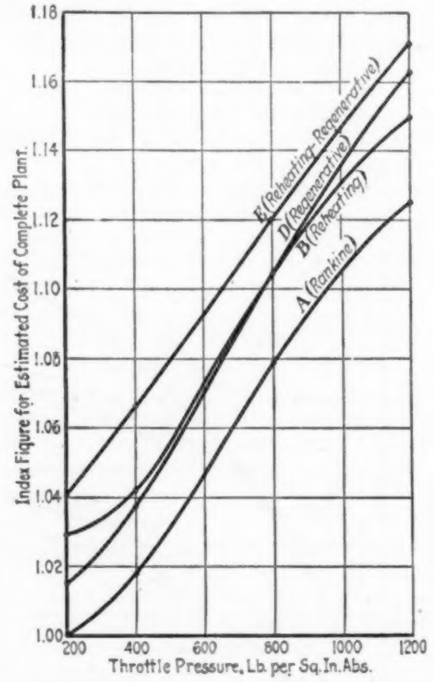

Fig. 11 Estimated Relative Costs of Complete Central Stations, Including Buildings and Land

A-curve from a value of 0.771 to 0.796 at 400 lb. and from 0.735 to 0.775 at 1200 lb. pressure. A straight line was then drawn through these two points, and from this line was subtracted the calculated reduction in efficiency due to throttling through the reheater and its piping. For cycle C there is no efficiency curve drawn, as we shall very probably never see a plant built to operate on this cycle. For curve D, or the one to be used with the regenerative cycle, a value of 74 per cent of its ideal is believed to be a fair one for a pressure of 400 lb., as it was obtained from careful calculations based upon actual guarantees. Through this point a straight line was drawn parallel to the one for the Rankine. For curve E, or the one to be used with the reheating-regenerative cycle having a reheat pressure of 40 per cent of the throttle pressure, it seemed proper to base values upon both B and D, since this curve is to represent the degree of approach toward an ideal involving both reheating and regenerating.

First Cost of Plant

From a careful analysis of condenser surfaces required, of auxiliary power, heating surfaces, piping system, and turbo-generators, the cost of all equipment which is affected by the steam pressure was determined and the corresponding index figures are given by the curves of Fig. 10. From these curves it may be noted that increasing the pressure from 200 to 1200 lb. per sq. in. will increase the cost of this equipment about 30 per cent for any particular cycle.

For the cost of auxiliary apparatus, the estimate was based upon motors large enough to operate the boilers at 300 per cent of rating.

The cost of the air heater was taken as $1.60 per sq. ft. of heating surface. This figure is intended to cover the cost of flues and all other expenses connected with the installation.

If to the cost of equipment affected by steam pressure there is now added the cost of land, canals, railroads, foundations, buildings, coal handling, miscellaneous mechanical equipment, and all electrical equipment except the generator, new index figures are obtained as shown by Fig. 11. From these curves it would appear that the 1200-lb. plant will cost only about 14 per cent more than the 200-lb. one to operate on the same cycle. For many cases this increase in cost will be greater when the higher pressures are used, for the reason that some plants will have a higher portion of the total plant cost dependent upon pressure than was used in this study. It is also clear that the plant built to operate upon the

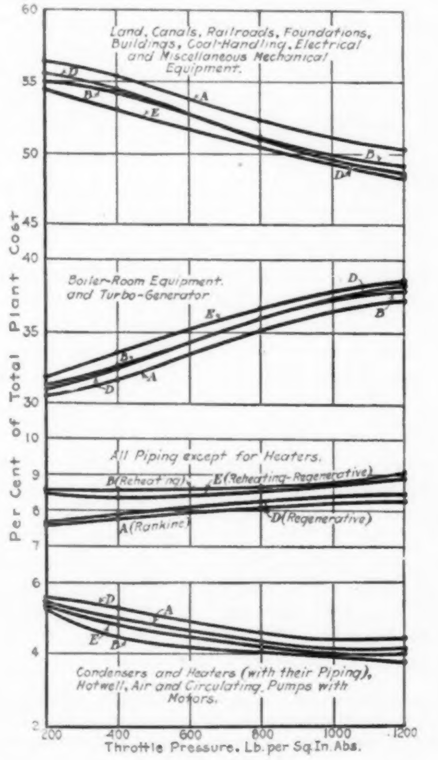

Fig. 12 Analysis of Plant Investment

Rankine cycle is appreciably lower in first cost than any of the others, and the reheating-regenerative plant is the most expensive through the entire range of pressures considered.

The cost of land, buildings, etc., was taken the same for each plant considered, but, due to the increase in the cost of equipment affected by pressure, this represents a decreasing percentage of the total plant investment as shown by the curves at the top of Fig. 12. These curves also show that in going from a pressure of 200 to 1200 lb. the investment in land, buildings, etc., varies from about 57 to 49 per cent of the total for nearly all of the cycles. Other curves of this figure indicate that, for pressures from 200 to 1200 lb. per sq. in., respectively, the turbo-generators and boiler-room equipment, with feed pumps and motors, require from about 31 to 38 per cent of the entire investment; the piping costs from about 7 to 9 per cent, and the condensers, heaters, and pumps with motors cost from about 5 to 4 per cent.

Fuel Consumption and Cost of Energy

The coal consumption of plants operating under different conditions as to steam pressure and cycle, is of great interest to engineers at the present time. For the pressures and cycles considered in this study the curves in Fig. 13 represent unbiased estimates which have been made in a manner that is believed to be reasonable.

For pressures of about 600 lb. per sq. in. it appears, from Fig. 13, to make but little difference what cycle other than the Rankine is chosen from the consideration of fuel alone.

From the curves of Fig. 14 it appears that with coal at $5 per

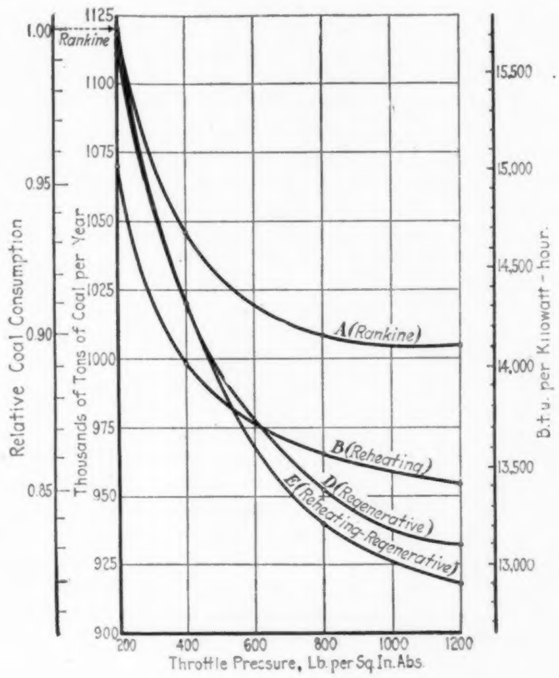

Fig. 13 Relative Coal Consumption of 200,000-Kw. Plants Operating on Various Cycles and Steam Pressures

(Capacity factor, 100 per cent; boiler efficiency, 84 per cent; throttle temperature, 700 deg. fahr.; exhaust pressure, 1 in. Hg abs.; heating value of coal, 12,300 B.t.u. per lb.)

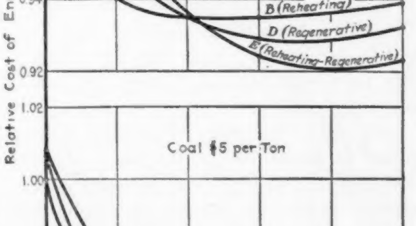

Fig. 14 Effect of Steam Pressure and Cycle on Cost of Energy at Switchboard of 200,000-Kw. Plant

(Capacity factor, 100 per cent; boiler efficiency, 84 per cent; cost of coal, $5 or $8 per ton as indicated; cost of energy taken as 1.00 for the Rankine cycle at 200 lb. per sq. in. abs.)

ton and a pressure of about 600 lb. it is immaterial what cycle is used other than the Rankine. It is also clear from these curves that with five-dollar coal, pressures higher than 600 lb. are not so attractive as sometimes believed. As the capacity factor is de-

(Continued on page 225)

The Export Problem of the Machine-Tool Industry

By W. H. Rastall,[1] Washington, D. C.

THIS meeting in reality represents the machine-tool industry of the United States, an industry that comprises more than 400 different establishments and whose production in a given year has been in excess of 200 million dollars. We in Washington are constantly giving our attention to the promotion of the export trade in the United States, and when an opportunity appears for us to meet together as at present, it seems desirable that we should give attention to the problem that we have in common, that of exporting American machine tools to the markets of the world.

There is a great deal that is very interesting, as the experience of the last ten years has been most remarkable. Previous to the war American machine-tool products were known throughout the world for their superior qualities, their high efficiency, their great productive capacity, their ability to produce with precision parts which allowed very scant tolerances, their labor-saving features, and even automatic equipment for the production of intricate parts. Also in these prewar years competition in the world markets was met from manufacturers in Great Britain and Germany principally, although there were some producers of lesser importance in a few other countries, and in these foreign markets there were frequently very earnest discussions as to the comparative merits of German, British, and American machine tools. Very frequently these discussions ended in the air because of the great difficulty involved in analyzing such problems—in part, at least, because of the many varieties of machine-shop equipment that might be considered. Even after careful research it is difficult to make statements on this subject that are entirely satisfactory because we depend to a great degree upon the statistics published by different nations, and quite commonly there are differences in classifications that make comparison difficult. However, if we can broaden the discussion and consider the exports of metal-working machinery, it can be shown that in 1913 the United States exported more than 16 million dollars' worth of such equipment, the United Kingdom less than five million dollars' worth, while Germany exported nearly $19^1/_2$ million dollars' worth. It will be noted that these figures showed Germany first in importance, followed closely by the United States, with Great Britain a poor third.

Effect of the War on Export Trade

The war probably affected the machine-tool industry as much or more than any other, and this is especially true as applied to the export situation. Machine tools were required for the production of an endless variety of commodities as needed for military purposes. The allied blockade prevented the further export of such equipment from Germany even had the military requirements on this industry been such as to allow these German exports to continue. A similar demand was felt in the United Kingdom, but, strange as it may seem, statistics show that throughout the war exports continued at about the prewar rate. On the other hand, the entire world called upon the manufacturers in the United States for a very greatly increased volume of machine tools, and our exports expanded rapidly from the volumes previously indicated to a total of nearly 85 million dollars in 1917. Upon the entry of the United States into the war about this time, it became very much more difficult to handle this export trade, in part at least because of the export markets and licensing provisions that were put in effect; and from 1918 the trade decreased to about 52 million dollars. Following the armistice it expanded again to about 59 million dollars in 1919, since which time there has been a further decline, and the returns for 1923 show this export trade at about 12 million dollars, or slightly under the prewar level.

With regard to our German competitors, it is difficult to present a concise statement that is fully satisfactory, largely because statistics of figures expressed in marks are practically worthless because of exchange fluctuations, and returns on a tonnage basis are also unsatisfactory because the machine-tool manufacturer produces an article that can scarcely be described in terms of weight. However, it can be stated that during the war the German export trade was very largely wiped out by the allied blockade. Following the armistice an earnest effort was made by German manufacturers to recover their old position, but many circumstances have arisen to make this difficult. Through 1921 and 1922 it was felt that the depreciating mark gave German manufacturers a peculiar advantage in the world's markets for such equipment, and, to a certain extent, these influences continue even now. On the other hand, it should be emphasized that information reaching Washington indicates that these reports have been very greatly

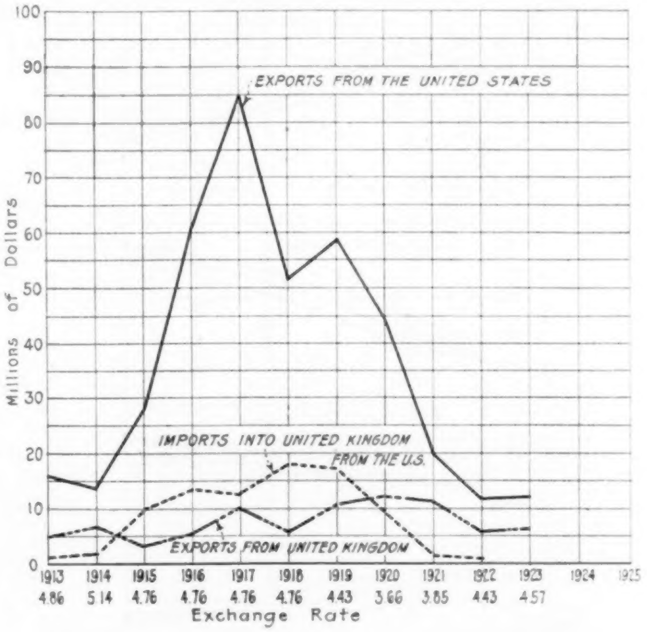

Chart Showing Exports of Metal-Working Machinery from the United States and the United Kingdom, also Imports of Metal-Working Machinery into the United Kingdom from the United States

exaggerated, and while it is entirely true in many instances that German machinery has been sold at prices 50 per cent or more under corresponding American quotations, it still remains true that the actual volume of German metal-working machinery shipped into the world's markets has not been very large, at least not so large as many of the reports in the press would lead us to believe. It is perfectly true that the situation is one that would cause the American machine-tool exporter a great deal of annoyance and worry, and undoubtedly in a number of markets stocks of German machinery are carried at prices represented by the depreciating mark which will interfere with certain classes of trade for some little time to come. However, it is gratifying to add that late in 1923 the utter collapse of the mark resulted in conditions that make it very difficult for German manufacturers to continue this trade. The indications are that German costs are now above world-market levels, and until conditions change in Europe, it is to be assumed that German competition has lost its force. As a consequence, in 1924 we find a situation where, generally speaking, the world's machine-tool trade is in the hands of British and American manufacturers. For this reason it is particularly interesting to give close attention to the competition to be expected from British sources.

Competition to be Expected from British Sources

As indicated by the accompanying chart, British exports have

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Presented at a joint meeting of the Engineers' Club of Philadelphia, A.S.M.E. Philadelphia Local Section, and the Machine Shop Division of the A.S.M.E., at Philadelphia, Pa., on March 25, 1924.

risen from the five-million-dollar level of 1913 in a more or less irregular way to about 12 million dollars in 1920, since which time there has been a decline, and at the close of 1923 these exports were approximately on a seven-million-dollar basis.

When traveling in the machinery markets of Asia or Latin America, one frequently encounters remarks that would give the impression that the British machine tool is greatly superior to the American product. In the newspapers of China or the Malay States one will frequently find articles calling attention to the great weight of a British machine tool, and while these articles rarely mention American products, it is often implied that machinery from this country is too light. Such statements even find their way, occasionally, into the reports from American consuls or other officers abroad. It is therefore interesting to note that in prewar years Germany was our best export market for metal-working machinery, taking on the average about $2^1/_4$ million dollars' worth of such machinery each year, and England ranked second, taking more than 2 million dollars' worth each year. It is a striking testimonial to the superiority of American metal-working machinery that these European countries absorbed such important volumes of this equipment in prewar years. It may be also added that during the war England imported nearly 20 million dollars' worth of such machinery in a single year. This statement is based upon the American returns. If instead we use the British returns, the 1918 total expanded to about 18 million dollars, but for purposes of comparison these returns are shown in the accompanying chart, and it will be noted that from the outbreak of the war until 1919 British imports of metal-working machinery from the United States were far greater than the total exports of such equipment from the United Kingdom at any earlier date. The fact that the British have found it desirable to import such large volumes of American metal-working machinery during the prewar, war, and postwar periods should in itself be sufficient demonstration of the superiority of American machinery of this kind, and provide adequate answer to the articles published in the press of Asia and elsewhere from time to time. However, the fact remains that, speaking generally, in earlier years British and German machinery has been of less highly developed types than that produced by this country. These European designs were frequently general-service tools, while the tendency in the United States was to produce a manufacturing tool, or even a single-purpose tool. Consequently, in the particular sense, the sales problem in the non-European markets frequently involved furnishing general-service tools suited to their requirements, and in these markets the American manufacturer seems sometimes to have missed his opportunity through offering equipment scarcely adapted to the needs of the individual buyer.

It is therefore obvious that in the cultivation of their foreign markets careful discrimination should be exercised by American machine-tool manufacturers between the European and the non-European demand. Obviously, manufacturers of production tools will find almost no demand for their equipment in Asia, Latin America, Australasia, or Africa. Their export interests lie almost exclusively in Europe. As a class, these seem to be the manufacturers who have made the best export showing. The conditions prevailing in Europe during recent years have very seriously interfered with this trade, and there is little that can be said on the subject until Europe starts to recover from the consequences of the war.

TABLE 1 U. S. EXPORTS OF INDUSTRIAL MACHINERY

Destination	Fiscal Year 1910	Fiscal Year 1913	Fiscal Year 1915	Calendar Year 1919	Calendar Year 1920	Calendar Year 1921	Calendar Year 1922
Europe, except Balkans	$14,148,759	$28,118,549	$38,218,925	$100,398,893	$ 90,730,853	$ 41,100,145	$ 23,236,149
Canada, Newfoundland, etc.	14,113,251	30,637,182	15,449,207	52,345,982	63,157,244	26,965,774	23,009,503
Other	152,354	455,227	282,107	4,640,170	3,439,801	2,707,063	905,864
Australasia	2,199,900	3,560,163	2,986,876	5,671,620	8,043,631	7,605,127	4,516,297
Africa	1,353,164	1,591,746	1,490,200	5,183,244	5,313,933	4,436,989	1,564,139
Total Latin America	13,483,948	19,085,692	11,059,820	54,561,206	88,258,643	70,334,654	28,020,356
Asia, except Asia Minor	3,666,244	4,610,045	3,777,440	61,879,671	65,308,252	55,598,449	31,036,614
Total	$49,117,620	$88,058,604	$73,234,575	$284,678,786	$324,252,357	$208,798,201	$112,288,922
Percentage To							
Europe	28.8	31.9	52.2	35.2	28.0	19.7	20.7
Canada	28.7	34.8	21.1	18.4	19.5	12.9	20.5
Other	0.4	0.5	0.4	1.6	1.1	1.3	0.8
Australasia	4.5	4.1	4.0	2.1	2.5	3.6	4.1
Africa	2.7	1.8	2.0	1.8	1.6	2.2	1.4
Latin America	27.5	21.2	15.1	19.2	27.2	33.7	24.9
Asia	7.4	5.7	5.2	21.7	20.1	25.6	27.6

Changes in Trend of U. S. Machinery Exports During Recent Years

But it is most interesting to note the changes in the trend of our machinery exports during recent years. Instead of considering only metal-working machinery, for a moment, if we consider the entire export trade in industrial machinery as shown in Table 1, it will be noted that in prewar years Europe absorbed about 30 per cent of our exports, while by 1922 this had declined to 20 per cent. In contrast to this, in prewar years the markets of Asia absorbed less than 8 per cent of these exports, while during the last two years they have taken more than 25 per cent of the total. It will also be noted that Latin America has increased in importance. The outstanding opportunity for export by American machine-tool builders in 1924 appears to be that for the American manufacturer of general-service tools as in the non-European markets, and these remarks apply to manufacturers of accessories as well as to the producers of tools themselves. The non-European markets have become very much more important than in prewar days. German competition for the time being is of little consequence, and the trade in these territories will fall into the hands of British or American manufacturers. The problem before the individual American manufacturer is to so cultivate these markets as to insure the sale of his equipment there. Inasmuch as European designs ordinarily represent less highly developed machines than those produced in this country, they can usually be offered at lower prices, and if the buyers in these markets are left to their own devices it is probable that they will purchase European tools because of attractive prices and with more or less disregard to quality. The American machine tool because of its superior engineering merit must command a higher price, and it is therefore up to the American manufacturer to make provision for such educational campaigns in these territories as will insure intelligent buying on the part of the more or less inexperienced industrialist of these non-European countries. The American manufacturer will find it necessary to arrange for constructive salesmanship on behalf of his products in each of these markets, and, in order that these campaigns may be of maximum effectiveness, these sales efforts should also be consecutive.

The opportunities for 1924 appear to lie particularly in two directions: first, in those markets which were formerly largely under German influence, and, second, in those markets that are showing natural expansion. It would appear that conditions are such that for some time to come difficulty will be experienced in securing satisfactory machine tools at commercial prices from German manufacturers. In prewar years such countries as the Dutch East Indies, Chile, and several others depended very largely upon German sources of supply for machine tools. Now that it is difficult to continue this trade, it is believed that the American manufacturer has a peculiarly favorable opportunity for sales effort in those markets, and every effort should be made to take advantage of this opportunity for the proper introduction of American machine tools in those markets. In markets that are showing natural expansion such as Japan, Central Europe, and British India, there is also a special opportunity. Recent experiences in some of these markets indicate quite clearly that American machinery is not as well supported as its engineering merit deserves. In 1918 the United States furnished about 80 per cent of the machinery imported into Japan. More recently this participation has declined very seriously. In British India in certain years the United States furnished as much as 25 per cent of the machine tools. This percentage has also declined of late and, inasmuch as these ratios in no way express the comparative engineering merit of the machinery offered, one would infer that the American trade suffers because inadequately supported by constructive salesmanship.

(Continued on page 205)

Some Limitations on Manufacturing to Close Limits

By B. H. Blood,[1] Hartford, Conn.

In manufacturing to limits the first essential is to be able to measure not merely to those limits but much more closely. The great majority of manufacturing operations in metal consist in removing surplus stock. To hold to any specified limits it is only necessary to stop at the right point. Our means of measuring must show us how closely we are approaching that point, and warn us before we pass it.

Thirty years ago very few machinists had ever seen a micrometer. Close dimensions were expressed on drawings in sixty-fourths of an inch. A drawing with sizes and tolerances expressed in thousandths would not have been intelligible. Yet the skilled mechanic worked in thousandths without knowing it. He would produce a drive fit, a sucking fit, or a running fit that was entirely serviceable, if he had the nicety of touch and the patience to do it. It took skill and time. He did not even aim at interchangeability. However, the general adoption of the micrometer, perhaps our most useful measuring instrument, has changed all this. The skilled mechanic has become the toolmaker and devotes his time and skill to providing the means whereby the unskilled operator produces by hundreds the parts of mechanisms which assemble without fitting. Better means for making close measurements have called for better means for manufacturing to close limits, and these in turn have called for still greater refinements in measuring instruments. Consider the steel balls used in ball bearings. They are made in quantity to limits of one ten-thousandth, and again selected by variations of a quarter of a ten-thousandth. This could not be done by the aid of micrometers alone.

What Precise Measurements Really Mean

It is unfortunate that many people have come to speak familiarly of thousandths and ten-thousandths without any conception of what those quantities mean in metal. Take, for example, a ring gage, nominally one inch. By holding it in the hand a few moments it can readily be warmed 16 deg. fahr., which would expand it a ten-thousandth. Take also a plug which fits the gage very freely—so that it can be felt to shake—and place a strip of cigarette paper one-quarter inch wide and one-thousandth thick, between the plug and the ring; the result will be a tight fit. Take another plug which will just drop through the ring by its own weight, and this third plug, which is just half a ten-thousandth larger, will fit so snugly that it will not shake off. A fourth plug, whose diameter is greater by another half ten-thousandth, will not enter the ring dry. By coating the surfaces with light oil the plug will enter the ring and slide freely as long as it is kept moving, but when it is allowed to come to rest for a moment the two are apparently frozen together, and cannot be broken apart.

There are no satisfactory means for measuring the diameter of this ring except by measuring the diameter of a plug on which the ring fits. But which one of these plugs does the ring fit? It must be that the oil film has some thickness, and yet the plug would not enter the ring without oil. It appears that the ring is actually stretched by the oil film.

This illustrates the difficulty of manufacturing to close limits when we have no direct means for measuring. We frequently send out plug and ring gages which have a "freeze fit," and the customer returns them claiming that the ring is smaller than the plug because he cannot get them together. The plug is capable of direct measurement, and measurements by different operators and in different laboratories, using different instruments, will agree more closely than some would believe. But who can say what is the inside diameter of this ring? We can expect no agreement on this point. Yet draftsmen will calmly place on their drawings tolerances which cannot possibly be checked, and leave the gage maker and the inspector to fight it out. Too often this is done conscientiously, in the belief that high-class work is thereby assured.

As an instance in point, in the early days of the late war the author was handed a roll of blueprints covering the test tools for one of the French gun carriages which our Ordnance Department had undertaken to manufacture. He was instructed to get out three sets of tools according to these drawings, in something less than the least possible time, and to submit as soon as possible an estimate of cost against which a purchase order would be issued. The job involved a cost of more than $100,000 and covered work ranging from close fits which could be secured only by selective assembly or hand fitting, to drill jigs as large as a table top, for armor plate which was to be bent to shape after machining. No tolerances were given on the drawings, but in the accompanying specifications occurred the innocent-looking clause: "All workmanship to be of the highest quality and to an accuracy of one ten-thousandth of an inch." The job was not done strictly to these specifications, or it would not have been done yet. But the tools were made and put into service before the author was able to get this wording modified so that he could safely submit a price and get an order for them.

Tolerances in Manufacturing Operations

Precision in manufacturing is not a thing to be set on a pedestal and worshipped. It costs money and time. Where it is necessary to the proper functioning of a mechanism it is worth whatever it may cost. In most mechanisms which require close fitting there are but few critical dimensions which need be held to close limits. For any manufacturing operation the tolerances given should be the widest which will assure satisfactory operation, but no wider. Anything closer than that is economically unsound. It is particularly unwise to place close tolerances on a drawing and then permit deviations by special dispensation. If work outside of established tolerance is usable, it proves that that tolerance is too close and should be widened in the interest of economy. Adherence to the established tolerances can usually be assured by correctly designed limit gages. The gages should be made inside the limits but as close to them as practicable, first cost and maintenance both being considered. They should then be used as fixed limits. The "Go" gage should go and the "No Go" gage should not go, and no gage should be forced, otherwise its life will be short.

Examples of Close Measurements

Let us consider some actual examples of close measurements which have been made, and some which could not be made, at least at any reasonable cost.

The company with which the author is connected recently made some thread gages for an automobile manufacturer, for which a definite gage-maker's tolerance of 0.0002 in. in pitch diameter was given. The customer rejected them as undersize. On checking them it was found that they were within tolerance, and they were accordingly sent back. The customer again rejected them, giving his readings on each individual gage. The author took them to the Bureau of Standards for checking. Using 5 lb. pressure on the anvils of their measuring machine, over wires laid in the angle of the thread, their readings checked those of the author's concern with a variation of 0.00001 in., or one-hundredth part of the thickness of a cigarette paper. Their readings were within the specified tolerance. But when using only 2 lb. pressure their readings were 0.00014 in. larger, a difference of two-thirds of the specified tolerance. The customer specified no conditions of temperature or pressure under which the gages should be measured, yet a reasonable variation in either one would have made all the difference between acceptance and rejection of the work.

The author's company have made up a set of 24 steel cylinders

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as shown in Fig. 1. They are of steel, highly finished, and according to their readings the greatest variation from 1 in. diameter at 68 deg. fahr. was +0.000002, −0.000000. They made a similar set of 25-mm. cylinders. The measurements in both cases were made by the interferometer, based on Professor Michelson's determination, some 30 years ago, of the number of cadmium-red light waves in the international meter, and the ratio between the inch and meter established by Congress in 1866.

Six of each lot of cylinders were sent to the National Physical Laboratory at Teddington, England, for checking. They were measured on the millionth comparator, against their own standard inch which was derived from the British imperial yardstick. They worked at their standard temperature of 62 deg. fahr., making the necessary correction for expansion at 68 deg. fahr. It was found that the cylinders would yield 0.000004 in. under the anvil pressure of 2 lb. which they used. The British inch is 3.3 millionths shorter than the inch used by our Bureau of Standards. Making corrections for these factors, their average reading for the six cylinders varied from that of the author's company by 0.8 of one millionth of an inch. The agreement on the metric cylinders was even closer, coming within 0.4 of one millionth of an inch.

This close agreement is the more remarkable when we consider the roundabout way in which the comparison was made. The British measurements were made by comparison with their bronze

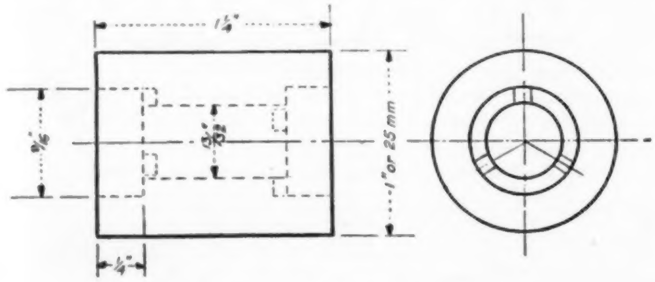

Fig. 1 Dimension Sketch of Steel Cylinder

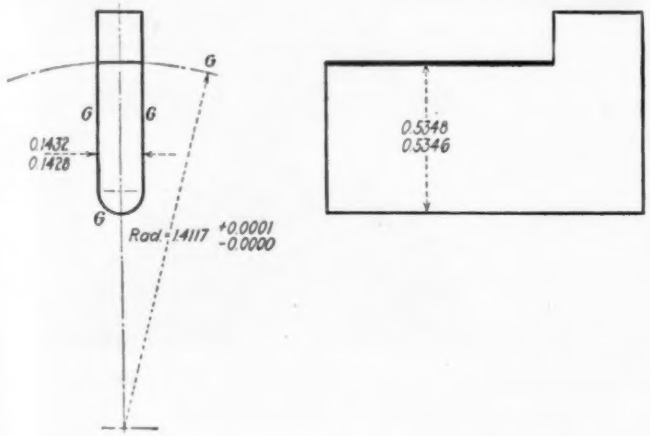

Fig. 2 Steel Blade Used for Punching Armature Disks

yard measure and their own calibration of it with the platinum-iridium meter of the Archives at Paris. Those of the author's company were made from a set of abstract figures expressing the length of a meter in terms of cadmium-red light waves, translated into neon rays, which they use for convenience. There was nothing approaching a direct or tangible transfer of measurements to any common standard. This confirms their belief that if every physical standard of length in the world were destroyed tomorrow, they could reproduce the meter and the yard with an error not to exceed one part in a million, using the wave length of light as a basis. So far as is known, that is not subject to change under constant conditions, and there is no present physical standard of length which is free from suspicion in that respect.

Practical Examples from Every-Day Commercial Work

Consider now some practical examples taken from every-day commercial business. Fig. 2 is a steel blade used by the thousand in a large automobile shop for punching armature disks. The tolerances are close but not particularly troublesome, with the exception of the radius 1.4117 with a tolerance of +0.0001, −0.0000. The author's company knew of no means by which this dimension could be measured or checked, and therefore refused several times to bid on the work. The purchaser resented this, saying that the parts had been made for several years from the same drawing, both in their own tool room and in four outside shops, without ever having a rejection on this point. Asked how the radius was

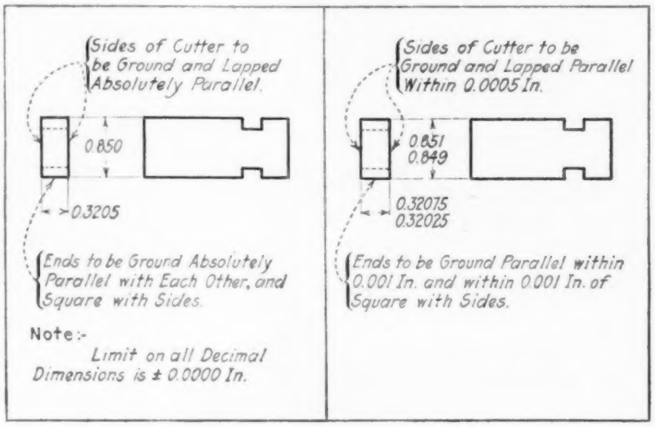

Fig. 3 Fig. 4

Figs. 3 and 4 Original and Revised Drawings of Cutter, Showing Changes in Tolerances

checked, no answer was forthcoming. But the purchaser finally agreed to remove the tolerance figures from this dimension, and to accept any product which they could not prove wrong. One may wonder why the figures were ever placed on the drawing.

Fig. 3 shows another piece, used in some quantity, on which a quotation was asked. Tolerances where given were close but possible. In quoting, the author's company interpreted ±0.0000 to mean that these dimensions were to be held within 0.00005 in.,

We request standard list prices and best discounts on double end reversible plug gages of your standard design made up to the following tolerances:-

GAGE TOLERANCES (ONE WAY OR TOTAL TOLERANCE)

CLASS	GO	NO GO
A	.00002	.00002
B	.00004	.00004
C	.00006	.00006
D	.0001	.0001
E	.0001	.00015

Fig. 5 An Inquiry for Gages

which could be done. "Absolutely parallel" was somewhat comprehensive, but the company offered to hold this to 0.000005 in., for they could measure that. "Absolutely square" corners could not be measured, but they undertook to hold this to 0.0001 in. on the short dimension, as an error of this magnitude would show daylight when an accurate square was applied.

The customer came back with the statement that the company's price was high, "probably because their tolerances were too close." He enclosed a revised drawing (Fig. 4) on which the tolerances were about ten times those the company had asked. A price was then made which was about one-third that originally quoted, and the order was obtained. In the first instance the pieces would have had to have been lapped and measured in a constant-temperature room. The change made it a fairly simple job of grinding.

The customer saw what his unnecessarily close tolerances would cost him.

Fig. 5 shows an inquiry for gages, apparently for ordinary shop use in a plant building motor trucks. No statement is made as to how or at what temperature the gages would be measured, nor as to the diameters required. The tolerance of 0.00002 on a 1-in. Class A gage represents the change in size which would be caused by a temperature change of 3 deg. fahr., or on a 2-in. gage by $1^1/_2$ deg. fahr. Such gages, though expensive, can be supplied, but of what use would they be in the shop? An hour's use would wear

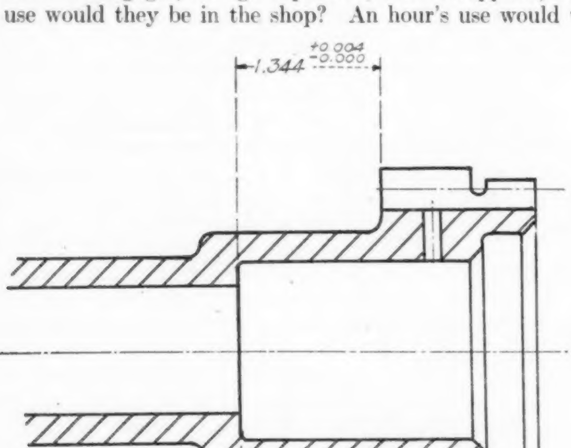

FIG. 6 TOLERANCES ON AN AUTOMOBILE TRANSMISSION GEAR

them out of tolerance. Notice also that in one case the gage tolerance on the "No Go" is greater than on the "Go." It should obviously be less, because the "Go" gage wears, and it wears *toward* the limit if its tolerance has been properly placed, while the "No Go" gage, if made within limits, wears *away* from the limit. It can wear but little unless forced, and there is no inducement to force it because to do so rejects work which might pass. It is logical to make the gage-maker's tolerance on the "No Go" half as great as on the "Go" member.

The shop drawings of a certain automobile transmission gear gave the dimensions and tolerances as shown at the bottom of Fig. 6. The only important dimension is from the shoulder to the bottom of the hole, shown at the top. This did not appear on the drawing until a lot of gears had been spoiled. The end of the gear fitted nothing and might have varied a thirty-second of an inch. The tolerances as originally placed made it necessary to hold two dimensions, one of them quite unimportant, to a tolerance of 0.002 in. each, while the revised figures above gave a single dimension with a tolerance of 0.004 in.

Smooth-running gears are about as difficult to produce as anything which passes through the machine shop, chiefly because of the lack of means for measuring the one essential dimension. Outside diameter, tooth thickness, backlash, eccentricity, etc., can be directly measured, but they are of secondary importance. Various involute testers have been devised, but they do not give directly the controlling dimension. In fact, the truth of the involute is not important so long as the two mating tooth forms are conjugate; that is, for perfect action each must generate the other.

Fig. 7 shows two spur gears meshed with each other. The heavy line represents the straight-sided basic rack from which the involute teeth are generated and with which they will run. The perpendicular distance P_n between the parallel faces of two adjacent rack teeth is the normal pitch, which is the perpendicular distance between two parallel planes making simultaneous contact with two adjacent tooth profiles. It is equal to the developed length of the arc on the base circle subtended by one tooth. It determines the angular movement of the gear while that tooth is in action. If the tooth spacing is not uniform this angular movement varies. If the mating gears are not conjugate in form and of the same normal pitch, the driven gear will either be bumped ahead or allowed to drop back as each tooth of the driving gear comes into action. An error of 0.0001 in. in normal pitch is of the same order of importance as an error of 0.001 in. in any other dimension of the gear. This is only beginning to be appreciated. The author has a beautiful booklet, issued about a year ago by the makers of one of the best-known fine cars in America, featuring their ground transmission gears, which it is claimed are held to an accuracy of 0.0005 in. A gear having an error of 0.0005 in. in normal pitch would be rejected by most makers of second-rate cars.

A Gage for Testing Gears for Involute Tooth Curves and Spacing

Fig. 8 shows an instrument devised to give, for the first time,

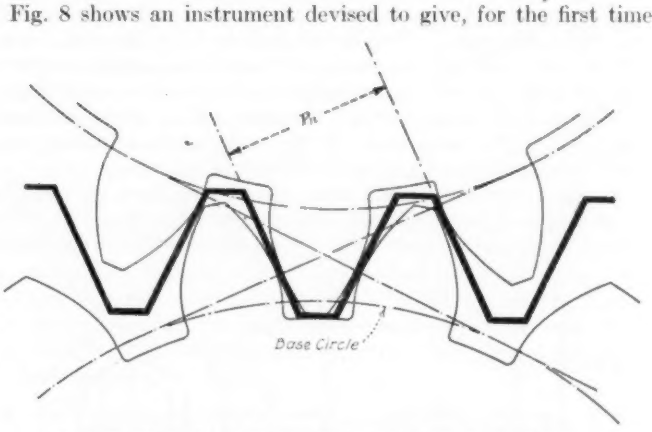

FIG. 7 TWO SPUR GEARS MESHED WITH EACH OTHER

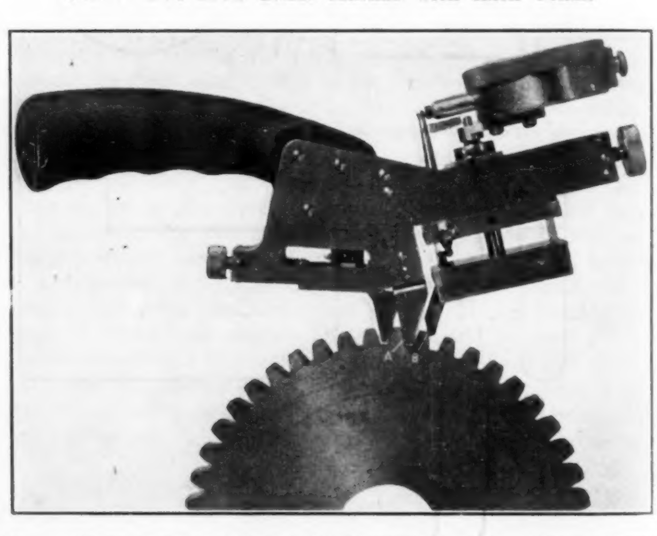

FIG. 8 INSTRUMENT FOR DIRECT MEASUREMENT OF THE NORMAL PITCH OF INVOLUTE SPUR GEARS

a direct measurement of normal pitch. It consists essentially of two plane parallel faces, A and B, corresponding to two rack teeth, the distance between which is variable and readable in ten-thousandths by means of a multiplying lever and dial indicator. By means of this it is possible to tell before removing a gear from the grinding machine whether it will run smoothly with any other gear whose normal pitch is known, and make corrections if needed; also to match up any gear of which there is a record. This is offered as an illustration of the value of direct means for measuring any dimension which must be held to close limits. Until this instrument was developed it was not possible to tell whether a gear would be satisfactory until it had been run with its mate. If it was not there was no way of telling what correction was needed. The one critical dimension could not be measured.

Summary

To summarize: In order to manufacture to close limits, it must be possible to measure to still closer limits.

(Continued on page 205)

Coal-Storage Systems

By H. E. Birch[1] and H. V. Coes,[2] Philadelphia, Pa.

This paper deals with the advantages and limitations of various devices and systems in a general way. Little is to be said of detail design, as it is the purpose of the Materials Handling Division to hold Local Section meetings at various centers, at each of which it is hoped to discuss in detail the various units covered by this paper. Particular attention is purposely given to the limitations of devices, as practically all that is written on the subject states only what a device was designed to do and how well it accomplishes its object.

The storage of coal at the power house to insure a constant and ample supply is as necessary as is a constant and ample supply of water, but unfortunately the coal supply must be maintained at the plant, necessitating a considerable investment in both handling facilities and in coal inventory. This seems to be necessary since past experience has proved that there are too many links between the unmined coal and the boilers. Mine strikes, railroad strikes, severe winters, high-priced coal, poor quality of coal, lack of transportation facilities, are some of the reasons for storing coal against future needs.

The amount of coal storage desirable depends on the factors of distance from source of supply, adequacy of rail or water connections, the seriousness of a possible shutdown, the probable future growth of the plant, and perhaps other local considerations which must be weighed separately for the particular plant in question. Our experience has been that few designers or owners can keep pace with future requirements. That which seemed adequate when built is woefully lacking today in size and capacity. Therefore it is necessary to keep well in mind the possible future expansion of the plant, not necessarily installing today for the future, but designing in such a manner that the future can be taken care of without scrapping equipment.

The storage pile should be adjacent to the boiler house and intimately linked thereto in such a simple manner that the coal to be unloaded can go either direct to the boiler house, or be diverted to the ground storage. The storage means adopted should be such that the coal is normally handled direct to the boiler house, treating the storage as a reserve.

Before considering in detail the advantages and disadvantages of the various systems in general use, it is well to give thought to those factors which are common to all systems, such as spontaneous combustion, unloading cars, rate of handling, etc.

Since spontaneous combustion is not a paper theory but is an actual fact, it follows that:

a Coal should be stored in such a manner that spontaneous combustion will be prevented; and that

b A storage system should be selected that can be utilized to easily and rapidly fight a fire which may occur through failure to store coal properly.

Spontaneous Combustion

The generally accepted theory of spontaneous combustion is the generation of heat by oxidation. Many devices store coal by the "cone" method, as shown in Fig. 1. That is, the coal is piled by dropping it from a single point, or in a straight line, the larger lumps rolling down the sloping sides of the conical pile. The pile thus formed consists of lumps at the base and fines above, as illustrated. Sufficient air is admitted at the base to start and maintain oxidation, while the blanket of fines prevents the escape of the generated heat. If the coal is discharged from an overhead telpher, trestle, or fixed conveyor the same condition obtains for the full length of the pile.

The idea should be to store coal without this segregation, in such a way that the interstices are filled with the fines, as shown in Fig. 2, where the piling is done in horizontal layers, producing a more or less homogeneous mass in which the oxidation is prevented or retarded due to lack of air.

Storing of sized lumps prevents spontaneous combustion, because while plenty of air is admitted to the pile, the elimination of the blanket of fines permits the generated heat to escape freely. This method, however, presents practical difficulties, since usually the plant will have to store ordinary run-of-mine or crushed coal, and the problem of using the fines as they are screened out of the coal as received would have to be solved, or a separate storage provided for them. The added expense of this, plus the cost of the screening plant, seems to eliminate this method of storing, as there is no advantage gained over the horizontal-layer method of piling.

In all coal storage piles there is a point at a certain depth below the surface which may be termed the "critical point." It occurs at that point which is just low enough in the pile to prevent the escape of the heat and at the same time not so low that air through the surface cannot feed oxygen to maintain the heating. It is generally conceded that the fire will occur at this "critical point." With screened coal in storage the air can penetrate much deeper to supply the necessary oxygen and the critical point is very low. With homogeneous storing the surface penetration is very limited due to the voids being very effectively filled with fines, and therefore the critical point is near the surface and is subject to change in temperature between day and night, and by winds, etc., causing it to move. If this point is deep in the pile it will not be affected by such outside temperature changes. Since the oxidation of coal is not an instantaneous process, it follows that if we can store coal in such a way that a continuous change of the critical point takes place, spontaneous combustion will be effectively prevented. It is doubtful whether the depth of pile has much influence on spontaneous combustion. Twenty feet seems to be a good average height, based on actual practice, although there are many cases where the pile is over 30 ft. deep.

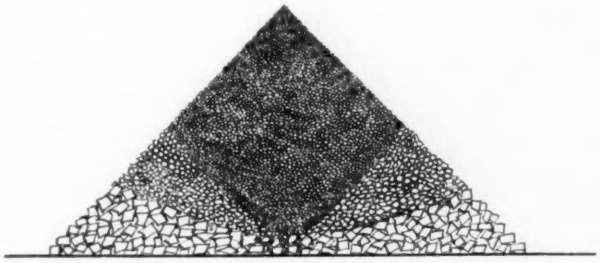

Fig. 1 Diagrammatic Representation of the Segregation of Lumps and Fines in Conical Coal Pile

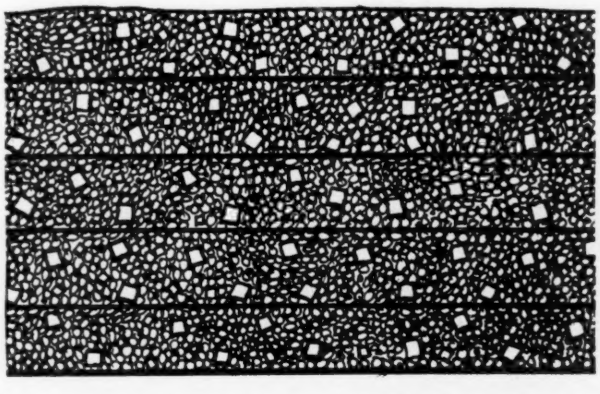

Fig. 2 Diagrammatic Representation of the Uniformity of Lumps and Fines in Coal Piled in Horizontal Layers

Under-water storage solves the chemical end of the problem, but adds materially to the handling problem. The handling facilities must be either a grab bucket or a cable drag scraper, and means

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must be provided to drain off the excess water before the coal is fired. The additional expense of such a system does not appear to warrant its adoption in view of the slight savings effected.

Unloading Railroad Cars

Unloading railroad cars presents a complex problem, since the types vary considerably and the coal may be frozen solid in the car. In the East practically all the cars are the bottom-dump type, and the usual practice is to employ a hopper in a pit beneath the railroad track, from which coal is taken by the material-handling device. This is true even where a grab bucket is used in order to avoid the loss of time cleaning out the hopper bottoms of the car.

The rate of unloading depends to a great extent on how fast the car can be unloaded. Under ideal conditions a 50-ton car can be unloaded in 20 minutes, assuming dry coal, summer weather,

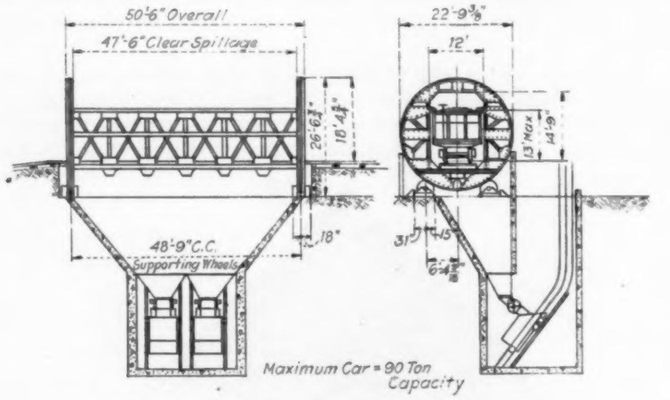

Fig. 3 Revolving Type of Car Dumper

and a car that has not been on the road long enough to pack the coal. Unfortunately, these ideal conditions are seldom realized. Assuming that the 20-minute rate can be maintained, it is necessary to make the track hopper large enough to hold sufficient coal to keep the material-handling system loaded while the next car is being moved over the hopper.

Practical considerations have shown that about 100 tons per hour is the maximum rate that can be attained when unloading 50-ton cars into a single-track hopper. For higher capacities it is necessary to use a double-track hopper.

With flat-bottom cars it is necessary to provide means to unload them. A grab-bucket crane is usually employed for this purpose, in which case the hopper should be wide enough to enable the bucket to discharge over the side of the car into the track hopper.

Car Dumpers. For very large plants, unloading at high hourly rates, it is necessary to use a car dumper in order to maintain the rated capacity of the system over a considerable period. About 200 tons per hour is the maximum that can be expected when unloading 50-ton cars into a double-track hopper.

Two types of car dumpers are in general use, one lifting the car in a cradle, and the other revolving it in a cage. The revolving type is shown in Fig. 3. It consists of a structural-steel cage holding one car, and is fitted with tires running on trunnion bearings. Clamps hold the car while the cage is revolving, these being operated by motors, as is the rotating mechanism.

The lifting-type dumper requires larger motors and a much larger structure, but the revolving-cage type requires a deep pit, which fact dictates the use of the lifting type on docks and where a deep pit is objectionable, regardless of cost. While the revolving type uses smaller motors, it discharges the coal 30 ft. or more below ground, from which point it must again be elevated. We are of the opinion that the power required to operate these dumpers is the same for the same amount of work done, that is, to get a stated amount of coal out of the car to a point, say, 50 ft. to 75 ft. above grade. The probable difficulty with the lifting type is that the larger motors necessary may cause too much of a "bump" on the line. In using either type of dumper, or even where only a double-track hopper is used, care must be taken to provide adequate track facilities to handle the traffic and to provide ample room for storage of both loaded cars and empties beyond the unloading point.

Specified Capacities. It is important when considering large installations to know whether the specified hourly capacity is based on what the equipment can be made to do in a one-hour test, or whether the intention is that the specified rate must be maintained over a ten-hour period. Is the unloading rate 250 tons per hour, or is it 2500 tons in ten hours?

There is a vast difference between these two capacities. For instance, a steeple tower operating a grab bucket unloading barges will attain its maximum capacity while breaking down the cargo, but when the barge is almost empty its hourly capacity is reduced by the inability to get coal to the bucket. The cleaning-up process requires considerable time, and this has a serious effect upon the total length of time to unload the barge, so that the average rate will be found to be considerably less than the maximum rate.

The same principle holds true in any system, whether for boat or car, but it is more pronounced in the boat because with a railroad car the hopper beneath the tracks can be made large enough to contain sufficient coal to feed the material-handling device while the car is being cleaned out, whereas with the barge, the grab bucket itself must clean out the coal.

Another point to bear in mind in connection with grab-bucket machines is that if the hourly capacity is distinctly specified by the engineer as a fixed number of tons per hour, the builder of the equipment is apt to rate his machine at this capacity, but stipulate that this is while breaking down the cargo (when unloading barges), and with an expert operator. If a machine is being installed to operate under average conditions, the capacity should be tested with these average conditions obtaining during the test, and the specifications should make this clear.

Frozen Coal. Coal in railroad cars will freeze, introducing a serious problem that cannot be solved by ignoring it. If the cars are to be unloaded by a car dumper, it is only necessary to thaw

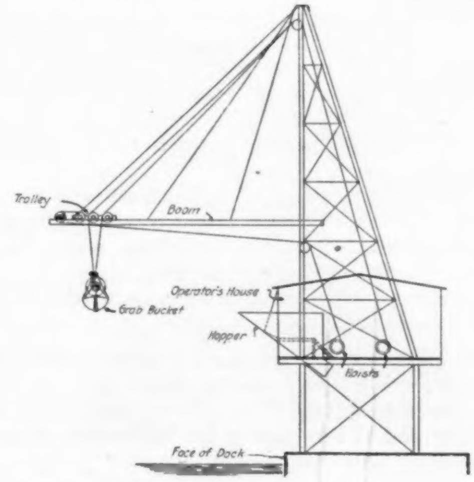

Fig. 4 Steeple Tower for Unloading Boats

out a thin layer of the coal next to the steel sides of the car. This can be done in a thawing shed employing hot air, or outdoors by a direct application of steam lances to the sides of the car. If the coal is to be unloaded into a track hopper, it is necessary to introduce steam into the bottom of the car as well as against the sides. In a few plants an overhead ram is used, shaped somewhat like a large chisel and acting like a pile driver. This device is motor driven and travels on overhead tracks longitudinally over the car. Its purpose is to break down the frozen coal to permit it to flow by gravity through the hopper doors.

Coal in ground storage will sometimes freeze to a depth of a foot in severe weather. If a grab bucket is used, it must be heavy enough to break through this crust to get at the loose coal beneath.

With a cable drag scraper it may be necessary to use dynamite to expose the loose coal. It is not necessary to break the entire crust as once the hole is made and coal dug out, the loose coal will flow toward this hole from beneath the crust, removing its support and thus automatically breaking the crust. With either system the

size of pieces that the crust must be broken into is not dictated by the ability of the material-handling device to transport them, but solely by the ability of the crusher to "bite" these lumps.

In cases where slack coal is stored, and where the coal goes through the crusher prior to being stored, provision should be made for recrushing frozen coal.

Unloading Boats

The Steeple Tower. A typical steeple tower is shown in Fig. 4. It is essentially a grab bucket controlled by a double-drum hoist, the rope leads operating over a trolley running on a horizontal boom which projects over the boat. A separate drum controls the movement of the trolley, with one man controlling the entire operation.

This device is a hoist, and does not attempt to transport the coal also, as do some other grab-bucket systems. When unloading a boat a grab bucket is necessary, but it is not necessary to keep coal in the bucket until it reaches the storage pile or boiler house. The capacity depends on the length of haul in any intermittent material-handling system. Therefore, the longer the haul, the larger the bucket and the higher the speed in order to maintain capacity. This is not satisfactory because as the bucket gets larger, the speed at which it can be handled decreases. The ideal plant is that which does the work for the lowest cost per ton, taking into account first cost and operating and maintenance charges. It is obvious that the first cost is largely controlled by the size of the bucket and its operating speed, and large high-speed buckets mean larger supporting structures and foundations, thus further increasing the cost.

One advantage gained by a low tower is that the operator is close to the barge and can clearly see the bucket at all times. This is important, because the fog and smoke usually prevalent along the water front make it impossible at times for the operator in a high tower to see the barge. Night work with a high tower is also very difficult.

The grab bucket, even on such a highly efficient device as a steeple tower, is by no means a simple device. There are six separate motions for the bucket per cycle, and each must be manually controlled, which slows down the operation. It does not seem susceptible to automatic operation, due to the nature of its duties. The difficulty with electrical operation seems to be mainly in controlling the load while lowering the bucket, when alternating-current motors are used. This is true of any hoisting equipment unless direct current is used, which presents no difficulties.

In considering capacities, speeds, etc., for a given tonnage, the size of the hatchways may determine the maximum size of grab bucket, regardless of other factors. Also, for high-capacity installations it will probably be better to use two steeple towers. The first cost will be little if any higher than for the larger tower, and positive insurance against interruption of supply is secured, as it is unlikely that both towers will be out of commission at the same time. Demurrage on boats far exceeds railroad-car demurrage, which is an additional factor in favor of the two smaller towers, even if their use were not dictated by the impossibility of working the larger bucket on the single tower through the hatchways.

Consideration must also be given to the kind of boats that will be received. Will they be narrow river barges, ocean-going barges, or vessels with masts? With any of them, shall we move the barge or move the tower, to completely cover the boat? If the former, care must be taken that there is sufficient room for this maneuvering, which is similar to the traffic problem which must be solved when locating a car unloading to a track hopper. The usual practice seems to be fixed towers, not because it is more economical to move the boat, but because the steeple tower, being a hoisting system only, is tied in with the means for delivering the coal to storage or to the boiler house.

Mast and Gaff. This device is used only for smaller installations, where the cost of a steeple tower would be prohibitive. Its use is confined to unloading and delivering its load to the dock or to an elevated hopper. It uses a grab bucket operated by a double-drum hoist, either steam or electric. The mast swings through a fixed arc and cannot be "peaked," as can a locomotive-crane boom. Since it is a fixed device, it cannot be used if the barge cannot be moved while being unloaded.

Stiff-Leg Derrick. This device is seldom used for unloading boats. Its cost is greater than the mast and gaff, and probably somewhat greater than the locomotive crane. It has one advantage over the mast and gaff in that its boom can be peaked. Like the latter, it is a fixed device, and the stiff legs often take up valuable space.

Locomotive Crane. This device has been very extensively used for unloading boats. With any grab-bucket machine the operator should be able to see his bucket at all times. With a barge almost empty, and at high tide, the top of the barge is apt to be higher than the operator, and he is forced to work blindly. It is a simple matter to extend the operating levers to an elevated cabin, and this slight additional expense has considerable effect on the hourly capacity. When the barge is being cleaned up, men are apt to be at work, out of sight of the operator, and this overhead cabin should be insisted on as a safety measure. When using a locomotive crane, a short track should be used to obviate the necessity of moving the barge any more than is necessary.

A locomotive crane performs very efficiently when confined to hoisting a grab bucket and delivering its load to some other device, but it is often saddled with additional duties which greatly lower its efficiency, as when it is used as the distributing medium, to shift cars around a plant, or for other duties, which because of its mobile nature it is frequently called upon to perform. When it must travel to stock out the coal it immediately ceases to function in its prime capacity as a hoisting device, with the consequent lessening of hourly capacity.

While it is true that in some plants the locomotive crane can admirably perform these various functions, yet it is frequently called upon to do all of this work when it should be restricted to the single function of getting the coal out of the boat. This it can do with small quantities just as well as a steeple tower, and much better than the mast and gaff or stiff-leg derrick. When comparing it with the steeple tower it must be remembered that it cannot lift coal as high as can a steeple tower, nor as swiftly, but as already pointed out, the height to which a steeple tower can raise the coal may be a disadvantage under certain conditions. The locomotive crane is very often used in plants where its function could be better performed by other devices, simply because it was purchased for use during construction.

Bridge Tramway. This device is used for the combined purpose of boat unloading, storing, and reclaiming coal. It is frequently used, since, because a grab bucket must be employed for the unloading service, it seems as though the simplest thing to do is to retain the coal in the grab bucket and merely run it back over the storage area. While this seems logical, consideration should be given to several disadvantages which become apparent upon study of the subject. The bridge tramway for any considerable capacity becomes a very expensive device, as a long bridge must be used to support the grab bucket over the storage pile; also, the size of the bucket must be considerably increased over the size that a steeple tower would use, because it is engaged in the dual duty of unloading the coal and running it back to storage. It cannot handle both of these duties without being made sufficiently large, in order that the time lost may be made up by the volume handled per cycle.

The length of the storage area parallel with the dock front can be no greater than the dock front itself, unless some horizontal distributing conveying means parallel with the dock front is employed. To do this, however, adds to the installation and operating expense, and requires a second handling of the coal to transfer it from this conveyor back into the storage area. The addition of this horizontal distribution merely deposits the coal in a long, narrow pile under the bridge, which must later be stocked out. Then, too, the expense of building a dock on the water front sufficiently strong and stable for the bridge-tramway load is very great.

In an endeavor to increase the hourly capacity of the bridge tramway, a belt conveyor is frequently put on the bridge to reduce the service that the grab bucket is called upon to perform. In this case the grab bucket confines itself to taking the coal out of the boat and depositing it immediately, as does the steeple tower. The difficulty with this idea is that the reclaiming of coal from the storage pile is not improved by the addition of this belt conveyor.

In addition to the above disadvantages there is the consideration of the future extension, as before mentioned.

The bridge tramway is a rigidly fixed device, as the span of the tramway is absolutely fixed. A common fault of the bridge tramway is that one end is frequently mounted on the boiler house or bunker, and this often fixes the dimension of the storage pile forever.

The locomotive crane is entirely opposite to this, as it is the very essence of a mobile device, and with it the storage is not so restricted as it is with the bridge tramway, although there are other disadvantages of the locomotive crane which will be considered later. Nevertheless the bridge tramway has been frequently used in the past, particularly on the Great Lakes, for handling coal and ore. It is in common use at steel plants for handling the stock pile, but we are of the opinion that its greatest use and growth were made in past years, when high capacities were not usual. One or two of the disadvantages mentioned are really more applicable to high-capacity plants where it is absolutely necessary for the grab bucket to discharge its load at the earliest possible moment, leaving to some other device the storing and reclaiming.

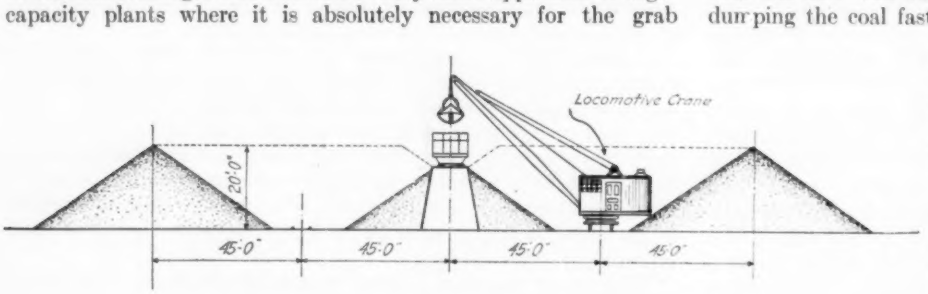

Fig. 5 Locomotive Crane and Trestle Storage System

At the 1923 convention of the Iron and Steel Electrical Engineers at Buffalo, N. Y., one of the papers treated of the wind and skewage hazards in bridge tramways and the special electrical control that has been developed to take the control automatically out of the hands of the operator until the condition of high wind or skewage has been remedied. That this hazard is a big factor in the operation of these devices, is well known, and apparently it is being given serious consideration in an endeavor to force safety automatically.

Man Trolley and Monorail Telpher. These two machines may perhaps be considered as brothers, the man trolley being used for larger capacities and the monorail telpher for smaller systems. These two devices may be used instead of any of the machines previously discussed for boat-unloading service, and, provided they limit their activities to this duty, there is no serious objection to them. However, due to their very nature they are apt to be misused by permitting them to run back over the storage area to store out the coal, which again brings the objection of reduced capacity and the difficulty of securing homogeneous storage.

With the man trolley, the overhead supporting structure has to be very massive because, unlike the bridge tramway, the entire hoisting equipment travels with the bucket, including the operator, and this means a very large and heavy boom projecting over the boat. This introduces the difficulty of having to provide means to raise or swing sideways this heavy boom, since very few installations can be made where the boom may be fixed.

If either the man trolley or the telpher is used to both unload the coal and to store it out, naturally it must store out and reclaim the coal in a single line. Assuming that the pile is 20 ft. high, it will be about 55 ft. across the base, and since the grab bucket will only be about 4 ft. wide, it is obvious that only about 55 per cent can be reclaimed by the machine because of its fixed path. The monorail telpher is only used for small capacities and in those cases where the runway must follow a tortuous path. The fact that both the man trolley and telpher have to carry their machinery with them, limits their size.

Storage Systems

Railroad Trestle. Perhaps the earliest type of storage system was the railroad trestle. Many plants were built to receive their coal on elevated trestles, but today it is becoming obsolete as a complete system. Some trestles are still being built, but most of them because topographical considerations force them. These cases are not to be mistaken for storage systems, for the trestles only serve the purpose of supporting the railroad cars. A single unloading point is used, and a separate storage system linked to this point. Trestles were started by the railroads years ago, principally for locomotive coaling docks, the idea spreading rapidly on the assumption that if all material-handling equipment were eliminated the resulting system would naturally be the best.

A railroad trestle is expensive to build. It is an obstruction on the property that effectively prevents a logical expansion of the plant. It does not permit much coal to be stored under it, nor does it store coal homogeneously. It stores coal, but cannot reclaim it. The embedded timber supports of the trestle are a prolific source of fires, which start at these timbers.

The railroad trestle permits very fast dumping, provided the coal will flow well out of the cars, but there is no advantage in dumping the coal faster than it can be stocked out. Because of difficulties in unloading railroad cars, a trestle will not attain a higher hourly capacity than can be obtained with a ground track and a track hopper. The problem of getting the coal out of the car is not solved by raising the car 15 or 20 ft. above the ground.

The trestle, to store a reasonable amount of coal under it, will be of such a height that the approach will be long and expensive. Furthermore, once built it is practically fixed forever, making it more rigid than any system using mechanical-handling means. If the ground contour is such that a natural depression cannot be utilized to avoid the approach, the system must be considered as dangerous, especially if the approach is steep, for at some time or other a car will get away and cause serious accidents.

Locomotive Crane and Trestle. Obviously we cannot afford the expense of covering the entire storage area with trestles, and must therefore use it merely as an auxiliary to the complete system, primarily as an unloading means and, in the case of a locomotive crane, as a means of forming a long pile, and so eliminating the necessity of the crane traveling with each bucket load.

Fig. 5 shows a typical cross-section through a coal-storage area, using a trestle and locomotive crane. The illustration gives the capacities per running foot, both with the crane tracks left open and covered. The tracks should not be covered, however, because of the difficulty of fighting fire, which is one of the dangers with this system due to the effects of conical piling. Conceding, then, that the tracks must be left open, it is apparent that for a continuous section 20 ft. deep there is more air in storage than there is coal, which means that either more property must be used or less storage maintained when comparing it with any system that will form a continuous pile, such as the bridge tramway or the cable drag scraper.

The trestle-and-crane system must have some means of transporting the coal when reclaiming. Obviously the crane cannot be permitted to do this for each small load. The most satisfactory way is to have the crane reload into the railroad car, or into a smaller privately owned car, and let the crane shift it to the boiler house. The car should be of the bottom-dump type, to avoid the time lost if the crane has to dig out the coal. The unloading hopper in this case should be extra large, otherwise the crane will have to wait until the conveying system has unloaded the car through a small track hopper.

Locomotive Crane and Conveyor. This system is practically identical with the previous one, except that a scraper flight conveyor or a belt conveyor is used to form the continuous wedge-shaped pile from which the crane stocks out. It has advantages over the previous system in that all the disadvantages of the railroad trestle are eliminated, and that the locomotive crane is confined to a single duty and does not have to act as a shifting locomotive. It reloads into a traveling hopper, which feeds the conveyor.

When contemplating the use of a locomotive crane in connection with either a railroad trestle or overhead conveyor, there are one or two other points which must be considered which also apply to the locomotive crane for any coal-handling service, either for unloading boats or cars or for storage of coal.

The vogue of the locomotive crane is not due entirely to its adaptability to the various coal-handling problems to which it is applied, but more because it is a definite, purchasable, handy device which performs very well a variety of duties, but no one duty exceedingly well. It can hoist coal like a steeple tower, but not as fast; it can swing and distribute coal like a bridge tramway, but not as fast; it can shift coal cars on the siding, but not as well as can a shifting locomotive; it can unload coal direct from cars, but not as well as can be done with track hopper discharging the coal in the ordinary way.

With any considerable storage area it is necessary to provide additional tracks, and these tracks, because they should not be covered, materially reduce the capacity of the storage. If in such cases the supply of coal comes in on a single-line trestle, it may be necessary to rehandle the coal to stock it out over a large storage area. The cost of the additional crane tracks required to do this is a serious item, particularly as they require a firm roadbed which cannot be obtained very well near a water front. The tracks must also be level, not only to permit the crane to run along the tracks, but also to keep level the revolving turntable of the crane.

A locomotive crane will need many repairs after having seen a few years of service, and therefore a machine shop must be nearby to keep the crane in order. This is such a serious item in large installations that a single crane should not be depended upon. At least two should be used if the plant is to be kept running.

The advantages of the locomotive crane seem to be that a single machine is used for doing all the work, and it affords greater flexibility for placing coal in storage and reclaiming. It is not a rigidly fixed machine, as the tracks can be relocated at will, and furthermore the crane is handy for other duties around the plant, which may be of greater advantage in small plants where the coal-handling duty does not require much of its time.

Storing and Reclaiming Conveyors. The locomotive crane-conveyor system is often modified where a large amount of storage is not required, by reclaiming the coal with a conveyor running in a tunnel underneath the coal car. Such a system is shown in Fig. 6.

This system is defective in that it is impossible to store coal in horizontal layers, and that only about 50 per cent of the pile is tributary to the reclaiming conveyor in the tunnel. This difficulty is similar to that of the monorail telpher, but the system has the advantage of being able to handle coal at a much higher rate than will the telpher system. Unlike the telpher, however, it must run in a straight line, and cannot go around curves as can the telpher. Another disadvantage is that the reclaiming tunnel serves as a good flue to deliver air to the bottom of the pile, and thus provides a means to start and maintain spontaneous combustion.

Cable Railway and Electric Cars. The cable-railway system has been principally in New England, along the water front. It consists of an endless-rope haulage, with cars attached to it at intervals, the whole running on an elevated trestle, usually built of wood. It has one decided advantage in that it uses cars, which in many ways is vastly superior to any system using continuous conveyors of any kind. Its principal disadvantage is that it can stock out the coal but cannot reclaim it, and it seems that in order to receive serious consideration any device ought to be able to perform both of these functions.

Another disadvantage is that in order to support it, bents have to be spaced about every 20 ft., and this in itself is apt to start a fire. This seems to be due to the formation of air pockets under the horizontal or inclined bracing members.

The capacity of the system can be easily increased by adding more cars and spacing them closer together. While the cable-car system is not subject to interruptions due to inclement weather, any trouble with the cable or with the driving mechanism affects the entire system. Also with the cable cars it is necessary for every car to make a complete circuit.

Because of these difficulties the electric car is being substituted for the cable car. Modern installations such as that of the new station of the Brooklyn Edison Company use steeple towers for unloading the barges and electric cars for horizontal distribution over the boiler-house bunkers. Because of the fact that the electric car is complete in itself, any trouble that is experienced with the mechanism affects only a particular car, and it can be taken out of service without interfering with the operation of the system.

If the electric car is working entirely outdoors, trouble may be experience from sleet and snow unless the feeder rails or trolley wires are protected. Electric cars are more dangerous than cable cars, due to exposed feeder rails. The foregoing objections, however, are not serious.

With either cable or electric cars a track scale may be used to automatically record the weight of the load passing over it. This automatic scale will weigh and record the weight to within one-half of one per cent of the true weight of the coal.

The electric car for this service is not a new development, one system having been in continuous operation for twelve years, another one for six years, etc. The difficulties experienced have been minor ones, such as the journal-box hangers breaking because they were cast iron instead of cast steel. Design difficulties of this nature are easily remedied, and a very satisfactory operation can be counted on. Like the cable-railway system, the electric car

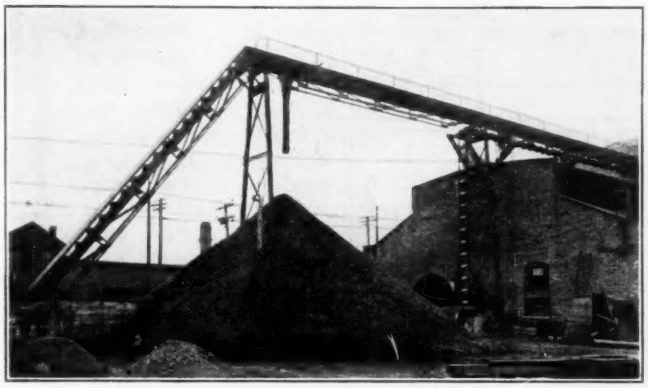

Fig. 6 Storage Pile Reclaimed by Conveyor in Tunnel

is purely a stocking-out device. It does not reclaim the coal but must work in connection with a reclaiming mechanism.

The Automatic Railway is another example of a device that stocks out but which does not reclaim. This is a gable-bottom car operating on an overhead track, the first portion of which has a rather sharp grade downward to give the car a quick start when it is pushed off the loading level. The next section of the track is on a 3 per cent grade to maintain the starting speed, and the last 50 ft. or so is level. Just before the car strikes the movable dumper which opens the doors, it engages with a cable fastened to a counterweight arrangement, the car being stopped by the energy expended in raising this weight. A movable dumper is set alongside the runway to open the car doors at the proper moment, so that when the coal discharges, the weight of the dropping counterweight imparts sufficient momentum to the empty car to return it to the loading point. The counterweight box is adjustable for weight, as this factor must be obtained by trial at the time of installation.

Depending as it does on the effect of gravity, anything which may reduce the running speed, such as high side winds, will affect the operation. This prevents the counterweight raising high enough to impart sufficient energy to return the car.

Cable Drag Scraper. The cable drag scraper is a device for storing coal on the ground and reclaiming it with the same equipment. It is designed for this service only and cannot perform any other, such as unloading boats or railroad cars. Such being the case, coal must be unloaded by some other device and delivered to some point within the boundary of the system, from which point the scraper can stock it out to fully cover the area. When reclaiming, the scraper position is reversed on the haulage cable, the coal being delivered back to the same initial pile, or to any other desired point within the storage area. An outline drawing of a typical system is shown by Fig. 7, in which a track hopper is used to unload cars and a skip hoist elevates the coal to a crusher which delivers it either to the bunkers, or to a chute which forms the initial pile from which the scraper works. When reclaiming, the scraper delivers the coal back to track hopper and thence to the skip hoist. Cable-drag-scraper systems have been built for capacities from 40 tons per hour up to 550 tons based on an average haul of 100 ft. Two of the latter size are being installed at the Essex station of the Public Service Electric Company

of New Jersey, which company also has one of 275 tons per hour at its Perth Amboy station. The Hell Gate station also uses the cable-drag-scraper system for storing and reclaiming its coal. Fig. 8 shows the scraper at Perth Amboy.

With this system the storage area can be of any shape and need not be level. Only one operator is necessary. The system reclaims coal with the same speed and ease with which it is stored. Fire in any part of the pile may be easily and rapidly dug out. The operator is not handicapped by having to be near the burning area to

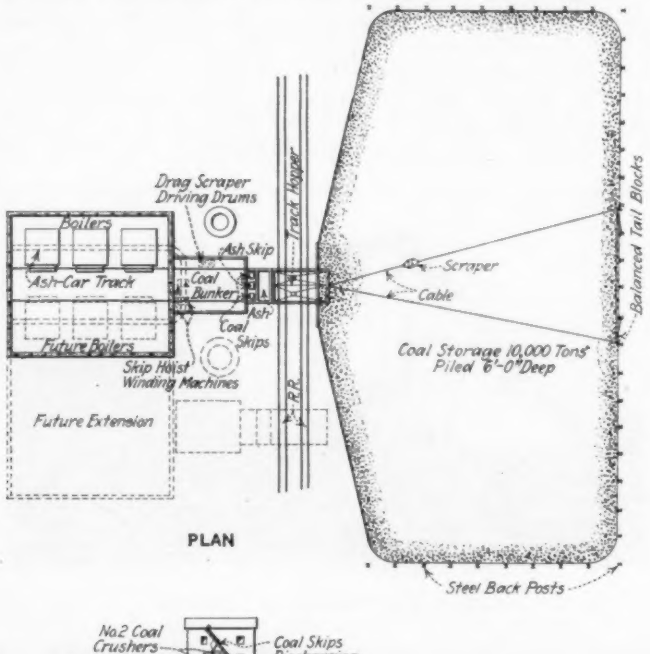

Fig. 7 Coal-Handling Plant of the Kansas Gas & Electric Co.

get to the heart of the fire, nor does he have to be at that point in order to spread out the burning coal so that it may be quenched.

The salvage value of the system is high because of its mobility. The only connection between the cable driving drums and the storage area is the cable itself, and therefore it will fit any other storage area should it ever become necessary to move it to a new location. Extremely large quantities of coal may be stored with hardly any appreciable increase in cost.

The maintenance of the system is low, due to the low cost of replacing the steel cable, which constitutes the greater part of the maintenance. The operating means is very simple, consisting only of a lever or handwheel which reverses the continuously revolving drums, or a remote motor-operated control on larger machines.

In some localities, where architectural appearance must be considered, a wall may be built around the storage area, very effectively hiding everything. On other types of storage systems, high superstructures may be offensive. Such a case would be a pumping station located in a park. The cable drag scraper handles coal at a very low cost per ton. When it is remembered that the outdoor storage pile is a reserve supply and is there primarily as insurance against interruption of supply, the simplest reliable system should be used to reduce the carrying charges on idle equipment. Further, it should be a system that can be operated at any time by any one, particularly if it is not called upon to work except when coal is not received on schedule.

The cable-drag-scraper system stores coal homogeneously. It also stores it completely over the entire area. There is no necessity to have twice the amount of ground, as is the case with some systems where tracks between piles must be kept open. Finally, since a reserve storage pile may not be called upon for weeks at a time, the handling system should be able to withstand the weather without undue deterioration. This the drag scraper can do, since the driving drums are inside a machinery house, the entire cable can be wound up on the drums, and the scraper can be stored under cover or protected with a tarpaulin. This leaves only the steel back posts, which are well able to withstand the weather.

The two difficulties with the system are cable wear and shifting of the tail blocks to different back posts. These are not very serious, however. In a well-designed system, using balanced and swiveled tail blocks and simple direct rope leads, the rope wear should not exceed that on a tramway or locomotive crane. The ropes leading across the field are supported by the coal, which is graphitic in nature and, therefore, "kind" to the rope. This support also relieves the rope from tension stresses, which would be present in a suspended cable.

The moving of the tail blocks presents little difficulty in the smaller systems, but is a serious factor in the larger ones. In fact, the large drag scrapers at the Adirondack Power Corporation and the Public Service Electric Company's Essex station are designed to use a moving car to carry the two tail blocks instead of using post anchorages.

The cable drag scraper is in the same family as the bridge tramway, but it is not such a ponderous device, mainly because it does not attempt to lift the coal. It is only a spreading device, and by limiting the problem to this simple duty, high cost and ponderousness are avoided. It is not necessary to consider the lifting of the coal in connection with storing and reclaiming, because there is usually a lifting device of some sort necessary for other reasons.

The Rope Cableway consists of a single-span cable supported by towers at each end and which carries a grab bucket

Fig. 8 Cable Drag Scraper at Perth Amboy, N. J.

hanging from a carriage or trolley. If it is a simple fixed span, it is open to the same objections as the monorail telpher or fixed conveyor, in that it stores the coal in wedge-shaped piles and cannot reclaim much more than 50 per cent of the storage. Sometimes the cable ends are anchored on movable towers in order to cover a rectangular storage area, in which case serious limitations are met. When this is done, a railroad track is usually run along one side of the storage area and the grab bucket digs directly out of cars. This does not begin to solve the basic problem, the first element of which is to get the coal out of the cars. This can be accomplished only with a track hopper or a trestle, eliminating from consideration the car dumper as being beyond the capacity of the system being discussed. A trestle is too expensive and too much of an obstruction to consider seriously, and a track hopper would have to be a digging pit extending the full length of the storage area. Such a pit would be more expensive than the trestle. The obvious solution, then, is to dig directly out of the car as much coal as possible and dump the remainder at a smaller central digging pit. This means of course that the entire device would have to be moved for each car, with the

possibility that, since the coal must be stored in a straight line opposite the pit, there will not be enough room there for it, which means rehandling. The rope cableway in which both towers travel has too many limitations, and therefore it is more common to pivot one end and support the other end on a tower which travels radially. This eliminates the unloading difficulties as a central dumping pit can be used, provided the railroad track can be brought to this point. The rope cableway is apparently an endeavor to improve on the bridge tramway, as it performs the same functions undoubtedly cheaper. Nevertheless we fail to recall any being used at blast furnaces where bridge tramways find their biggest field, though there may be other limitations which prevent this such as cantilever ends, etc. Since it performs the same functions as the bridge tramway, we may consider the remarks under that heading as applying to the rope cableway.

Portable Conveyors have a field all to themselves for very small capacities where the installation of the larger system cannot be justified. They may be of the belt conveyor type or the chain-and-bucket-elevator type. These devices have been used in some instances where equipment of a more permanent nature should have been used, with a consequent "black eye" for a machine which has fully justified its use in many small plants, retail coal yards, etc., that otherwise would still be employing shovels and wheelbarrows, or similar expensive methods at the present high labor rates.

When these portable conveyors are made too big, while they are actually portable they are heavy when well built, and if they are not well built they will not stand up under the rough usage they get. The labor required to move them around is considerable. At least two men are necessary with a 24-ft. machine, and from 4 to 8 men for the very large ones.

Portable conveyors form a conical coal pile, which is dangerous, and they require a large amount of repairing due to their necessary lightness. It is virtually impossible to secure long life, freedom from breakdown, etc., except by using good, heavy construction, and this is difficult because the machine is supposed to be portable.

Miscellaneous Systems. A few methods have been used for coal storage which can be mentioned for the sake of completeness. Side-hill storage is sometimes used when the topography favors it. This system makes use of a steep hillside, dumping the cars at the top of the hill and building a retaining wall at the foot to retain the coal.

Temporary storage piles have been built by the railroads and others by dumping the cars on the ground and then raising the track to the new elevation and so on until the pile is high enough. This is probably the worst of all systems. The segregation of sizes natural with this system is exaggerated by the continued crushing of the fines by the cars and locomotive, which operate on the center line of the pile, where the fine coal is concentrated. The system also is unable to fight the fire which its method of storing induces. The cost of storing and reclaiming with this system is very high, in fact, high enough in one year to pay for and operate a mechanical system.

The stiff-leg derrick mentioned earlier under Unloading Boats, may be used for storing and reclaiming, but it is a very rigid device, occupying valuable property, and it cannot swing through a full circle. Neither can it reclaim all the coal it stocks out, the outer edges of the pile flowing away from the maximum radius of the boom. To overcome the limitations of the stiff-leg derrick a full-circle crane-type derrick has been devised, using a horizontal boom and a traveling carriage. The boom is supported by a tower and is extended at the rear to carry the hoisting and trolleying drums and a counterweight. This type stores the coal in a circular pile, digging out of cars or out of a dumping pit. To store coal the bucket must be lowered; closed on the coal; hoisted vertically; moved horizontally; the boom revolved; the bucket opened; the boom revolved back to the pit; the empty bucket moved horizontally; making eight distinct operations per cycle. It is obvious, therefore, that this device is not suitable for high capacities. While it stores coal by the conical method, it has the advantage over some systems that it can get directly to the heart of a fire and spread the coal out easily and quickly for surface quenching.

Belt-Conveyor Stacker. This system uses a long belt conveyor built on the ground, and a stacking device which is essentially an immense tripper to which is attached a short pivotal belt conveyor. The ground conveyor discharges the coal to the stacker, which can swing through 180 deg. of arc and can be raised or lowered in a vertical plane to prevent dust and breakage when discharging. The stacker travels on ground tracks which span the main belt conveyor, thus permitting coal to be stored on both sides.

A reclaiming device operates on the same tracks as the stacker, and comprises a pivoted belt conveyor having at its end a loading device.

The Ideal Storage Plant

Any system of cranes, drag scrapers, conveyors, or trestles should be measured by comparing its advantages and limitations with the following yardstick:

1 It must be of such design that it can be easily extended both as to ground covered and hourly capacity to take care of future requirements

2 It must meet the Operating, Maintenance, and Interest (O. M. I.) formula. Do not base the ton cost of handling and reclaiming the coal on the annual coal consumption, as all coal consumed may not be stored

3 Boats or railroad cars must be unloaded rapidly and economically

4 Coal should be stored in such a manner that spontaneous combustion is prevented

5 It must be a system that can reclaim the coal economically and one which can quickly and easily fight fire

6 The system should be flexible enough to allow for future extensions and should not block growth of the plant. It should be mobile enough to readily adapt itself to an entirely new location

7 The trackage facilities should be laid out to properly handle the coal traffic without interrupting the general plant traffic. Provide gravity facilities if possible for handling cars over the track hopper.

Few, if any, storage systems possess or require all these ideal conditions. Storage facilities must be adapted to meet local conditions.

After months of study in comparing the pros and cons of the various ways and costs of solving a problem, it is often very difficult to choose the best system. While the disadvantages and limitations of each system must, of course, be studied, perhaps the most important comparison is the relative operating, maintenance, and interest costs, which have been referred to in a previous paragraph as the O. M. I. formula. This is the dollars-and-cents test and should always be made.

The first cost of a plant should be considered last. Too often it is considered as being of prime importance, and the plant is eventually replaced by another in which the O. M. I. costs are lower. In other words, it is the cost per ton of coal handled, all factors considered, that counts. The common fault in most systems is the maintenance cost. Under this head come reliability and dependability. These are the aggravating and costly faults we usually get when first costs are too low.

To consider the O. M. I. formula in order, the operating cost is simply the labor cost per ton handled, plus the cost of power, oil, etc. This often may be profitably reduced by increasing the hourly capacity without a corresponding increase in the interest charge.

Maintenance is a more elusive factor. It not only includes the known and expected replacement costs and repairs, but covers the indirect and unfigurable losses, due to breakdowns, shutdowns, and derangements. The best way to avoid these costs is to examine the device or system in the same way that an automobile would be examined; that is, its general reputation, the fact that it is largely bought and well thought of, and that the manufacturer has been in business for a considerable time and expects to stay in the business of building the automobile that he has sold. How the device or system is thought of by the user is often much more valuable than how it figures out on paper.

The interest cost always looms up as an important factor, but we are gradually learning to consider the other factors more seriously, especially when our own personal experience proves that our worries as to costs on the plant we operate are seldom, if ever, in regard to the interest cost. Plants are rarely discarded because of their interest cost, and seldom discarded on account of labor cost unless this

is exorbitant. It is more common for a plant to be discarded because it is too small for the job, or because it is unreliable or costs too much for repairs and upkeep.

Another view of the case is this: The interest and labor costs can be seen and determined accurately beforehand, but the dependability, repairs, and breakdown expenses cannot. Too often the one responsible for the selection of the system is not concerned with the ultimate cost per ton, but with the lowest initial investment, which as pointed out, does not always result in the lowest cost per ton of coal handled.

Fundamental Economic Data Required

The authors had hoped to be able to present charts showing all the comparative costs per ton of coal handled for several systems, and the total investment in the system, for various capacities and tonnages in storage, but it was soon found that too many conflicting apparent facts had to be reconciled. The designing, consulting, and operating engineers need just such data to aid them in picking out the system that is basically the soundest economically, particularly for the industrial power plant as well as for the large central station.

In view of the importance of this subject, the authors suggest that the Materials Handling Division appoint a committee to study and collect the necessary data for such charts and to report their findings and recommendations to the Division, much in the same manner as was so effectively done in the case of the Formula Committee.

For it must be borne in mind that our present immigration policy is, in effect, a protective tariff on labor, and as such is at present operating to raise labor costs. Thus labor-saving devices are more than ever being seriously considered and must needs be so considered as long as labor charges are a large item in a particular method of handling.

Discussion

THREE closely allied papers were presented at the Coal Storage Session of the A.S.M.E. Annual Meeting: namely, Factors in the Spontaneous Combustion of Coal, by O. P Hood; Economic Phases of Coal Storage, by F. G. Tryon and W. F. McKenney; and the immediately preceding paper by Messrs. Birch and Coes. The first of these papers was published in the December, 1923, issue of Mechanical Engineering, and the second in the February, 1924 issue.

In opening the joint discussion which followed the presentation of the papers, W. L. Abbott, who presided over the session, said that periodically the coal industry in the country was subject to upsets. These upsets were temporary and might be minimized or perhaps altogether avoided if coal users were sufficiently provident to lay up a supply of coal near the point where it was used. With the exception of coal practically every commodity which entered into our everyday use was stored up in quantities sufficient to tide over any temporary emergency. Why this was not done with the coal had been considered by the Federation of American Engineering Societies and it had appointed a Committee on Storage of Coal which had been studying the matter for some six months. The result of that survey would shortly be presented. In advance of the report it could be said that the Committee did not find any good reason why coal should not be stored in greater quantities than it had been in the past, although it found that coal was now stored in increased quantities over what had been the practice a few years ago.

The reason why coal was not being stored was due mainly to the large initial cost of such storage with no scheme for financing such storage, and to high carrying charges. The question of insurance on this large supply of coal was also important. It was also not generally understood how this supply could be conveniently and inexpensively handled into storage and out again as needed. Moreover it was supposed that coal deteriorated greatly in heating value from being left in an outdoor storage. But perhaps above all the reason which deterred most users from storing coal was the potential danger of the whole pile taking fire and burning up. But the studies which had been made of coal, under such conditions as prevailed when exposed to air outdoors, were now so well understood that it was possible with confidence to tell a coal user how to store his coal so that it would not take fire. When this information was generally disseminated there would be a pronounced increase in the practice of laying up a store of coal to guard against interruptions.

If the transportation companies would install a differential rate for coal transportation—a little less in summer and a little more in winter—if the coal miner would consent to a wage rate which would be a little less in summer, when the demand was light, and a little greater in winter when it was heavy, the coal-storage problem would settle itself.

J. E. Davenport[1] submitted a written discussion in which he stated that the transportation industry was very much interested in the question of coal storage. The 9000 commercial bituminous coal mines in this country were served by some 180 railroads directly, and by all of the railroads in the country indirectly. Practically the entire output of these mines was handled by the railroad industry: to be exact, in 1920 and 1921, 97 per cent of the coal which was moved was transported by rail. This output represented one-third of the entire railroad freight tonnage; further, these railroads consumed approximately 28 per cent of the output of the mining industry.

The economic effect of more general coal storage upon the transportation industry was best viewed by inquiring into the operation of that industry during the year 1923. Considering the period from the first of January to the middle of November, or the first 46 weeks of the year, coal production in 1923 had averaged 10,600,000 tons per week, the minimum production during any one week totaling 9,629,000 tons and the maximum production 11,740,000 tons—these maximum and minimum production figures representing a spread of from 11 per cent above to 9 per cent below the weekly average production. In considering weekly production, the weeks containing generally observed holidays had been eliminated. For the three years preceding 1923, covering the same period or the first 46 weeks of each year, it was found that the weekly production in 1922 varied from 52 per cent above to 53 per cent below the average weekly production; in 1921 from 43 per cent above to 20 per cent below the average weekly production, and for 1920 under conditions of practically constant demand, from 22 per cent above to 16 per cent below the average weekly production. These figures were quoted for the purpose of showing that during 1923 bituminous coal had been flowing from the mines much more steadily than during the three preceding years. This bituminous production in 1923 represented approximately half a million tons per week more than the estimated required production to sustain present American industries. However, the transportation industry had been able to handle this maximum production during that year with practically no car shortage and no congestion. This more regular production, no doubt, had been of great assistance to the railway industry in taking care of the largest volume of business they had ever been called upon to handle.

The foregoing facts suggested that economically the railroad industry had sufficient capacity to meet the service demands of present-day industry, provided some means could be devised to more nearly equalize the load factor by eliminating peak demands for coal.

A more general coal-storage policy would decrease the stress upon the transportation industry, eliminate the so-called coal-car shortage, increase utilization of all types of cars, equalize traffic throughout the year, decrease labor turnover, and decrease coal-handling costs.

In dealing with all phases of the coal-storage question, attention should be given to the fact that at the present time the transportation industry was called upon to handle considerable quantities of bituminous coal over unnatural routes requiring long haul where it was entirely possible to supply coal of similar quality by short haul. This feature should be considered as it was barely possible that in order to secure various grades of coal for storing an additional burden might be placed on the transportation industry.

In conclusion, it should be stated that the railroad industry had

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[1] Supt. Fuel & Loco. Performance, New York Central Railroad Co., New York City.

done its share toward solving the coal-storage problem, and that on October 1, the railroads had in stock piles 15,600,000 tons of coal, this figure representing slightly more than 10 per cent of the coal used by them during 1920.

C. G. Spencer[1] wrote that the closing sentence of Mr. Hood's paper pointing out that the tendency to heat differed in different coals, suggested in many cases a way out of the difficulty. A remedy which could often be applied, particularly in the East where there was a wide range of coals available and where existing equipment and local conditions made the storing of coal in layers prohibitive, was to purchase coal which did not heat, thus removing the cause of the trouble. Mr. Spencer stated that he had applied this remedy successfully when operating a central station on the Great Lakes. It had been the custom for many years to purchase slack coal high in sulphur and to expect fires in the storage piles as a matter of course. A change to New River coal stopped spontaneous combustion and incidentally resulted in better plant economy.

Bituminous coal was not always stored in districts where the small sizes of anthracite competed with bituminous and where a large reserve storage must be carried. The choice of fuel might be made in favor of anthracite, one of the controlling factors being that it could safely be stored to any depth. The statement that it was doubtful whether the depth of pile had much influence on spontaneous combustion would be questioned by engineers who had contended with fires in piles of bituminous coal with a tendency to heat. This did not apply with anthracite in which, so far as Mr. Spencer was informed, there were no records of spontaneous combustion.

Most Illinois and some other Mid-West coals slacked very rapidly in the air, and a lump exposed to the atmosphere for a few days slacked and became fine. It was doubtful with this fuel if storing in layers would have any appreciable value over conical piling. These instances were cited to illustrate that the correct solution for storing under one set of conditions might not be correct for the next set.

In designing equipment for unloading and storage an effort should be made to utilize the same equipment either wholly or in part for both services. Two examples where this had been done were at the Baltimore refinery of the American Sugar Refining Company and a central heating plant now under design where radically different systems were employed, neither of which was outlined in the paper. In the former coal was received by barge and unloaded by a grab bucket by means of a low tower which traveled the length of the coal dock. The bucket trolleyed through the tower on a boom which extended over the storage area. A conveyor belt paralleled the dock and took the coal either directly from the barge to the plant or from storage to the plant; the same tower, grab bucket, and belt being used in both cases. In the heating-plant installation coal was received in railroad cars and elevated to a belt above the overhead bunker, from which it either went to the bunker or was spouted to yard storage.

A word of caution was in order against committing a project to elaborate an expensive coal-handling and storage plant, in view of the many changes now taking place, particularly in the adoption of powdered coal and in the possibilities offered in low-temperature distillation of locating the storage pile remote from the plant and piping the gas to the furnaces.

Perley F. Walker,[2] in a written discussion, said that it was to be regretted that Messrs. Birch and Coes had not gone with greater detail into the overhead-bridge type which was employed so generally at the storage docks on the Great Lakes and other points where coal was handled and stored in large lots. From the standpoint of tonnage, these dock handling systems represented a large portion of the total amount of storage in the country. At the Lake Superior docks alone, in the neighborhood of Duluth, there was a storage capacity of twelve million tons or more, equipped almost entirely with various forms of the overhead bridge. These docks had been described in detail in a paper presented before the Society in 1917 by G. H. Hutchinson.

There were two kinds of coal storage. One was merely a process of keeping on hand coal sufficient to meet the needs of the establishment for a period of days during which coal shipments might be interrupted. It was insurance, pure and simple. The second was seasonal storage, conducted on the plan of purchasing at some time of year when market variations gave a price that was favorable. It was an interesting thing to note that in this latter plan the time of year at which coal prices for steam purposes were habitually low was different in the different sections of the country. This was brought about largely by variations in transportation. In one section of the country the heavy movement of mine-prepared coal to the Great Lakes gave a low price for screenings in midsummer. In other sections, notably in the West, the low price for steam coal under present conditions was usually later in the season.

These two kinds of storage gave rise to different considerations in the matter of cost, which in turn had an influence on the selection of equipment. If storage was for insurance purposes only, the cost of storage was chargeable to insurance. Under such conditions the amount of coal that would be handled into and out of storage was comparatively small. The apparatus would be employed for but small portions of the time, and the condition lent itself to the advantage of that form which was of low initial cost and, presumably, entailed a relatively high cost of handling. Hence it was that apparatus eminently well suited to one condition might not be at all suited to conditions at another plant. With storage of the second kind it was conceivable that conditions might arise where it was proper to distribute the cost of storing coal over the total tonnage consumed, instead of over the tonnage actually into and out of storage. If by the placing of coal contracts at a time when the market was favorable a considerable portion of the year's supply went into storage according to the seasonal plan, it would mean that the storage equipment was being employed as a means for reducing the annual fuel bills of the company. Under such conditions the cost of storage, measured on the tonnage basis, should be spread over the total annual consumption.

George A. Orrok[1] wrote that, under normal conditions, the question of storage versus no storage was wholly one of dollars and cents. Messrs. Tryon and McKenney cited a range of from fifty cents to a dollar a ton as the premium the consumer had to pay in losses, fixed charges etc., for insurance against no coal or high prices.

How much more than the average market price would the consumer pay if he purchased his coal from month to month as he needed it, or perhaps gambled with the market and made yearly contracts? The authors' diagram for the country in general indicated a variation year after year of not over 50 cents until the unusual year of 1916. Their district diagrams indicated a seasonal fluctuation as high as 80 cents per ton in one district and as low as 25 cents, in an even year, in another district.

It appeared that it was impossible under present conditions to make out a case for the storage of coal except as an insurance against interruption of supply or excessive rise in prices due to such interruptions. Storage on the customers' premises usually added from 15 per cent to 20 per cent or more to the cost of the coal and might with certain coals result in excessive deterioration. The change from reasonably good coal to half-burnt coke or ashes and clinkers was not an economical one for the owner of the coal.

In helping to modernize a rather important coal field in Nova Scotia which depended almost entirely on water for the shipment of its coal, Mr. Orrok wrote that he had had to take into consideration the fact that from the first of November until the first of May very little coal could be shipped. It was imperative that the output of the mines during the winter months, or at least 70 per cent of it, should be stored, and this was done in conical piles (in some cases) 90 ft. high with no trouble from fires. As the bulk of the shipments took place in the summer, it was almost imperative that the vessels should be handled on their arrival at the port with the greatest possible speed, and to do this coal storage on the shipping pier was maintained. For any such condition as obtained in Nova Scotia it was imperative for the coal company to store at the pit mouth, in cars, and at the shipping pier.

As a general proposition, Mr. Orrok believed that practically every coal mine needed a small storage at the pit mouth to equalize conditions.

[1] Engr., McClellan & Junkersfeld, Inc., New York City. Mem. A.S.M.E.

[2] Dean, School of Engineering, University of Kansas, Lawrence, Kan. Mem. A.S.M.E.

[1] Consulting Engineer, New York City. Mem. A.S.M.E.

John W. Lieb,[1] who opened the oral discussion, said that the experience of the utility companies on the Atlantic seaboard would seem to indicate very definitely that the storage of coal at the point of consumption was not an economic process. It was a definite liability and no money was saved by the storage of coal under their conditions. The storage of coal, however, was an absolute necessity for the safe conduct of those utilities which, as all knew, were of ever-increasing importance in the industrial life of the communities. In periods of stress the utility companies must get coal in sufficient quantities even if they had to pay greatly increased prices. And it was not merely the question of paying a high price in the spot market that was important, but the fact that in times of stress only wretchedly poor coal might be obtained. But the problem arose especially where the utilities had very definite and peculiar relations to the local regulative authorities—where they had coal-adjustment charges which they passed on through a coal-adjustment clause to the consumer—that if coal was stored when it was available, this might be at a high price and an enormous stock of coal might be on hand when the market price had fallen several dollars a ton.

The characteristic of the coal as shown by chemical analysis was hardly a gage as to its liability to spontaneous combustion. The heat element was of course of outstanding importance, but it had been found that some coals which would seem from chemical analysis to indicate a comparative immunity from fires in the coal pile had shown just the contrary, and the best coals from a B.t.u. standpoint were not necessarily the best by any means for storage.

W. E. Symons[2] said that the locomotives of our railways burned a great deal of fuel. The fuel bill for the preceding year, including water, had been $550,000,000, or more than 11 per cent of all operating expenses, about $26,000,000 of which was for water. The remainder was for fuel, principally coal.

By proper methods of safeguarding the handling of this fuel, a saving might easily be effected of five or, possibly in extreme cases, ten per cent, which would mean $25,000,000 to $40,000,000, and like savings could be effected in the industrial field.

Then again, with regard to the matter of pilfering or stealing coal, from bins, cars, and engine tenders or coal that had fallen off, which practice was seldom condemned and rarely ever punished, much saving could be effected.

Dr. Charles R. Richards[3] said that many people had the impression that coal put in storage deteriorated materially. That did not seem to be the case because in one investigation undertaken at the Engineering Experiment Station at the University of Illinois coal that had been in storage for probably ten or twelve years seemed to have lost not more than one or two per cent of its heating value. It did actually gain in weight slightly; that is, there was some oxidation, so that the net loss was almost negligible. In boiler tests conducted with coal that had been in storage for a long period of time it had been found that very distinct differences in handling the coal were evident, that the coal could not be used under the same depth and draft conditions equally well with freshly mined coal. And yet where the fireman understood the handling of it, he was able to get perfectly satisfactory results.

There was a tremendous opportunity for education of the power-using public along these lines, and Dr. Richards believed that the committee appointed by the Federated American Engineering Societies would prove effective in correcting some of the false impressions current about storage and the value of stored coal.

Robert Kleinschmidt[4] said that the social aspect of coal storage as distinct from the direct economic effect was important. At the mines there were seasons of the year when the miners were laid off for half or even three-quarters of the time. The waste of unskilled labor in such a procedure was a very serious economic loss to the nation. To prevent this waste, storage at the mouth of the mine seemed to be necessary.

W. B. Chapman[5] said that anthracite coal could be stored without difficulty because it did not break up and because it was sized. In storing bituminous coal it was broken up and to quite an extent segregated when it was not desired to have it segregated according to size. Powdered or semi-powdered coal lent itself to efficient combustion and also was free from such difficulties in regard to storing. Mr. Chapman believed that it would later be possible to use coal that was not as finely pulverized as at present. It was sometimes stated that there was greater efficiency in burning pulverized coal because of its fineness. That was not true. The reason for the greater efficiency was because it was burned in suspension. Gas was burned efficiently because it was burned in suspension, and the same was true of oil. The trend, therefore, was going to be toward burning fuel in suspension and toward a coarser pulverization, in fact, no pulverization at all; a grinding of a coal to perhaps 10 mesh, which was very easy, at a cost of about ten cents a ton, instead of pulverizing it to pass a 100 of 200 mesh, which would cost from 50 cents to $1.50 a ton according to the quantity pulverized per day.

Regarding the individual householders, who wasted the greatest amount of coal and handled it most inefficiently, if the time ever came when a semi-pulverized coal could be used, it would be taken into houses from the trucks in tubes, much in the manner of vacuum tubes or compressed-air methods of conveying fine coal, and much inefficiency in individual use would be done away with. Then again, burning coal in suspension lent itself to the use of regulators so that the coal could be burned automatically as required, with further gain.

A. J. German[1] said that his company had in a small way attacked the problem of storing coal so as to prevent fires. They had two piles of coal which they started early in 1923, about 9,000 tons in one and about 13,000 tons in the other. At pile No. 1 they had to crush the coal first before they could put it in storage, and it was generally known that this was more dangerous than non-crushed coal. The coal in pile No. 2 was stored without crushing. From analysis of the coal it was found that the very best of results could be expected with regard to starting fires. Pile No. 1 was about 20 ft. high, all in one heap. Pile No. 2 was not higher than 18 ft. Surprisingly, no trouble had as yet been experienced with pile No. 1, but considerable with pile No. 2.

The explanation would seem to be that when pile No. 1 came out of the hopper from the coal car it was picked up with a big derrick and spread over a large circle. When the pile was about five feet high, another little pile was dumped next to it, and this was kept up until there was a whole circle of piles about five feet in height. When the whole area to the foot of the derrick was covered in that way a fresh start was made and more coal was piled on each little pyramid until the whole pile was covered to a height of about 15 ft. Then no coal came along for about a month. Pile No. 2 was longer and not circular like No. 1. Consequently the coal was moved around a little more. But in pile No. 1, immediately after the right height was reached, holes were driven in the piles. A long bar or pipe, about two inches in diameter, was used with the cone end at the bottom. Two light sawhorses with planks underneath them were placed on top of the coal pile, upon which two men stood and thrust the pipe down further and further until there was a hole clear down to the bottom. To prevent the coal from falling in and filling up the holes a lot of wooden boxes about six inches square were built so that they would project about a foot above the hole. In all, there were about 900 boxes in pile No. 1, and spots were found here and there that heated up faster than other places. When the temperature marked by crosses on the boxes reached 150 deg. fahr., trouble was expected. A number of holes were driven at such danger points and the temperatures immediately came down, presumably due to the introduction of air.

It would be very difficult for the large central stations with their large amounts of coal to drive holes in this manner, but they might be able to use a clamshell bucket, or they could actually drive the pipe down with a small pneumatic hammer.

A. A. Adler[2] said that if a particle of coal was taken and suspended in the atmosphere it would oxidize at every temperature. Then if the heat carried off by the ventilating air was less than the heat generated by the oxidizing process, the coal could be kept from oxidizing at too rapid a rate. If the ventilation of the coal

(Continued on page 233)

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[4] Harvard Engineering School, Cambridge, Mass., Mem. A.S.M.E.
[5] Pres. Chapman Engineering Co., Mt. Vernon, Ohio. Mem. A.S.M.E.

[1] Ch. Engr. Scovell Mfg. Co., Waterbury, Conn. Mem. A.S.M.E.
[2] Const. Engr., New York City. Mem. A.S.M.E.

Resistance of Various Aluminum Alloys to Salt-Water Corrosion

Results of Tests of 24 Different Compositions Under Conditions Analogous to Service on Shipboard, Showing That Corrosion Troubles Hitherto Experienced Have Been Due to the Use of Unsuitable Alloys

By D. Basch[1] and M. F. Sayre,[2] Schenectady, N. Y.

A handicap to the increased use of aluminum has been the lack of reliable information as to its resistance to deterioration in service. Under severe service, as when exposed to the weather along the seaboard or on ships, or in industrial districts, where SO_2 fumes from smoke are present, aluminum articles have sometimes corroded very rapidly or even shown internal disintegration, warping and cracking up into small fragments. The natural result has been to deter its introduction, and to an unwarranted degree.

In connection with the introduction of aluminum into general use by the General Electric Company, and in particular for use on board ship, this question became of large enough importance to justify an investigation on a relatively large scale. This investigation took up first the general properties of the alloys, and then the effect of corrosion under salt-spray conditions analogous to service on shipboard.

The results of the salt-spray tests were conclusive, and rather surprising, showing a very wide range in rate of corrosion as between the different alloys, some alloys deteriorating more than thirty times as fast as others, a difference amply great enough to show that the real trouble in the past lay in the use of an unsuitable alloy rather than in the inherent properties of the aluminum itself.

This work should be of interest both because of the results themselves, which are given in the accompanying tables, and because of the methods used to obtain definite quantitative values in the corrosion tests.

The complete investigation included also studies of foundry properties and of foundry difficulties of various alloys, and of their machining qualities.

The Salt-Spray Testing Apparatus Used

For the corrosion tests the salt-spray testing apparatus of the generally adopted form (developed by the Bureau of Standards) was used. Air at slight pressure, furnished by a small blower, was passed through a water bottle to cleanse and moisten it, and then to one or two glass atomizers in the salt-spray box. This box, Fig. 1, was made of slate, keyed together with pins, and with joints filled with a pitch compound. A wire-glass cover was used. The box measured 28 x 28 x 20 in. inside, and was supported so that the rear edge was 6 in. higher than the front edge. The samples hung from glass rods supported on a tarred white-pine frame, the frame being doweled together to avoid use of metal, and were far enough from the bottom so that no direct spray from the atomizers reached them. The atomizers stood in the salt solution, which filled the lower half of the box two to three inches deep.

Certain changes were made from the Bureau of Standards methods.[3] First, a 3 to 4 per cent solution of sea salt in distilled water was used instead of a stronger solution of common salt. The sea salt, made by evaporating sea water, contains all the ingredients in ordinary sea water, and so, while giving reactions in the box much more complex than with ordinary salt, represents much more perfectly the actual conditions on shipboard or near the sea.

The 3 to 4 per cent solution was originally chosen because it is the average concentration of ordinary sea water. It has two distinct advantages over stronger solutions approaching full concentration: (1) it is apparently more active chemically than when stronger; and (2) when the weaker solution is used, the salt does not crystallize out on the sample being tested, so that there is much less difficulty in keeping the sample clean.

Further, in order more closely to simulate actual conditions, the samples were removed from the salt-spray box daily and dried for one hour at 40 deg. cent. The conditions on shipboard are best represented by severe salt mists alternating with dry periods when the apparatus will dry off, and not by constant moisture.

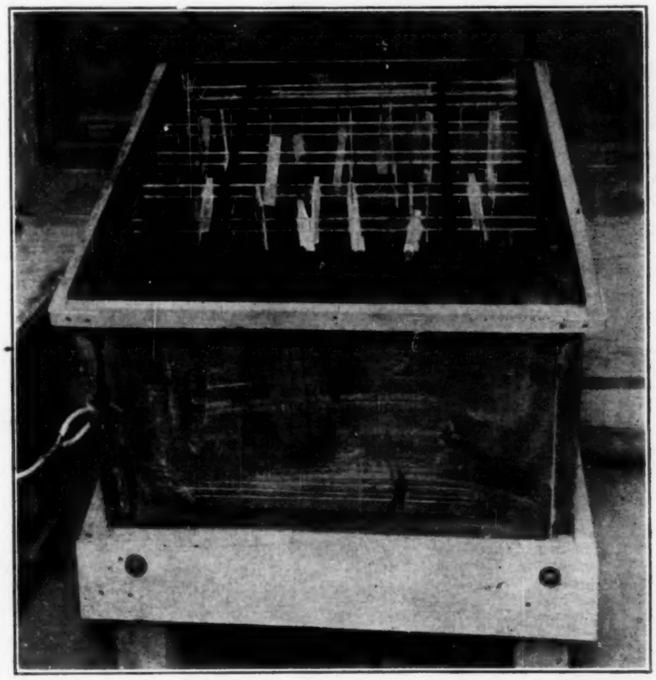

Fig. 1 Salt-Spray Box with Cover Removed Showing Method of Suspending Test Pieces in the Spray

This drying partially or completely dehydrates the products of corrosion and so alters the conditions of corrosion. The samples were not washed off during the entire run, in fact every precaution was taken to avoid knocking off any of the "fuzz" which collected on the samples. At biweekly intervals the samples were weighed, and the gain in weight determined. This gain in weight during the first two to four weeks, until the fuzz grows too thick, has proved to be a very satisfactory criterion of the rate of corrosion of aluminum samples.[1]

The daily drying hardens the deposit on the samples, the mild mist in the salt-spray box is not severe enough to wash it off, and with the dilute salt solution used little salt is deposited on the samples, so that the gain in weight is very closely proportioned to the amount of oxygen absorbed, and so to the amount of metal oxidized.

By use of heating coils placed beneath it, the temperature in the salt-spray box was maintained at 30 to 35 deg. cent. Higher

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[3] See Bureau of Standards Circular No. 80 describing methods of salt-spray testing.

Contributed by the Aeronautic Division and presented at the Annual Meeting of The American Society of Mechanical Engineers, New York, Dec. 3 to 6, 1923. All papers are subject to revision.

[1] As an alternative to measuring the gain in weight, there is that of measuring the loss in weight of the metal itself; but this involves completely removing all the oxidized deposit, and this deposit is frequently so adherent, or so held in pits in the metal, that it is hardly possible to remove it without taking some of the metal also. On this account, the method of measuring gain in weight seems to offer distinct advantages where it can be used.

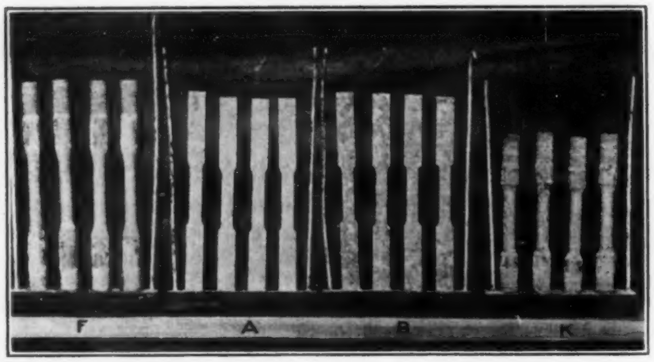

Fig. 2 Appearance of the Four Alloys in Initial Series Least Corroded After Eight Weeks in a 4 Per cent Sea-Salt Spray at 40 Deg. Cent. Ambient Temperature

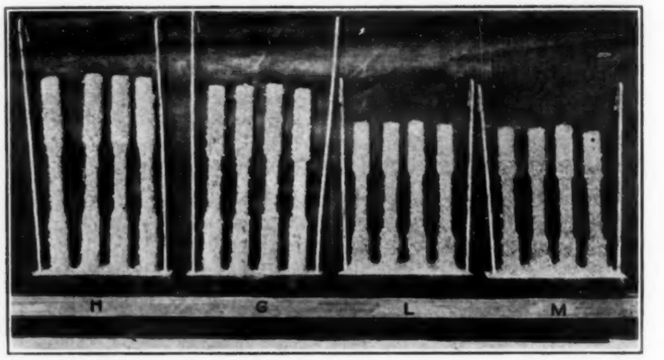

Fig. 3 Appearance of the Four Alloys Most Corroded After Eight Weeks in a 4 Per cent Sea-Salt Spray at 40 Deg. Cent. Ambient Temperature

temperatures did not prove feasible because the water in the box evaporated rapidly and soon became concentrated enough to deposit salt on the atomizer nozzles.

These modifications seemed to make the salt-spray test better adapted to the particular investigations which the authors had in mind, and possibly to other investigations as well.

In coöperation with the leading aluminum manufacturers, sixteen alloys were chosen for the initial series of tests. Eleven more were later tested from time to time, so that the list to date includes twenty-four different compositions, three of these being tested with and without heat treatments. Much help was received from the Aluminum Company of America, the Aluminum Manufacturers, Inc., The Baush Machine Tool Co., The British Aluminum Co., and the French Aluminum Co., both in the selection of the alloys to be tested and in the preparation of the specimens. The nominal chemical composition of the various alloys is given in Table 1.

TABLE 1 NOMINAL CHEMICAL COMPOSITION OF ALUMINUM ALLOYS[1]

Alloy No.	Type	Cu	Mn	Zn	Mg	Fe	Si	Ni	Remarks
Initial Series									
A	Rolled	..	..	..	..	..	..	..	Commercially pure sheet 99 + % Al
B	Rolled	..	1.5	..	..	..	..	..	
C	Rolled	4.0	0.5	..	0.5	..	..	..	Annealed
D	Rolled	3.0	0.5	..	0.5	..	..	..	Heat-treated
E	Rolled	3.0	0.5	..	0.5	..	..	..	Annealed
F	Sand-cast	..	..	..	..	..	..	..	Commercially pure 99 + % Al
G	Sand-cast	6.6	1.0	2.3	..	..	..	1.25	
H	Sand-cast	8.0	..	..	..	..	..	..	
I	Sand-cast	3.0	..	8.0	..	1.3	..	..	
J	Sand-cast	..	..	..	..	..	..	2.8	8.8% Sn
K	Sand-cast		1.5	..	..	..	..	..	
L	Permanent Mold	12.0	..	..	..	..	..	..	
M	Permanent Mold	10.0	..	..	0.3	..	..	..	
N	Sand-cast	2.0	1.0	..	..	..	..	..	
O	Sand-cast	6.5	..	..	0.5	..	..	1.5	
P	Sand-cast	6.5	..	..	0.5	..	..	1.5	Heat-treated
Second Series									
Q	Forged	..	..	7.0	1.25	2.0	..	..	Heat-treated
R	Sand-cast	4.0	..	..	0.25	..	..	..	
S	Sand-cast	4.0	..	..	0.25	..	..	..	Heat-treated
T	Die-cast	4.0	..	..	0.5	..	..	..	Heat-treated
U	Sand-cast	..	..	..	..	..	5	..	2% Sn
V	Sand-cast	..	..	..	..	..	5	..	
W	Sand-cast	..	..	..	5.0	..	..	..	
X	Sand-cast	..	..	8.0	..	..	..	..	
Y	Sand-cast	4.0	..	..	1.5	..	..	2.0	Heat-treated
Z	Sand-cast	1.5	..	..	..	..	5.0	..	
AA	Sand-cast	..	..	20.0	..	..	..	..	

[1] Where not otherwise stated Fe and Si will ordinarily be present in amounts not greater than 0.5 per cent each, due to use of commercial aluminum ingot.

Factors Involved in Evaluating Corrosion Resistance

The data desired included the hardness and the tensile properties of the alloy, as ordinarily determined, and the resistance to salt-spray corrosion, the latter to be determined as nearly as possible quantitatively. The factors involved in evaluating resistance to corrosion may include:

1 The depth to which pitting extends, as determining the time required to perforate, and so ruin, an article;

2 The amount of material affected by corrosion in a given time, as determining the amount of deposit likely to form inside an apparatus, hindering its working;

3 The loss in strength, as caused by the actual loss of material or as caused by the roughening of the surface due to pitting;

4 The loss in strength, as caused by any internal disintegration of the material, evidenced in the season cracking of brass, or the warping and cracking of certain zinc alloys; and

5 The appearance. An article spotted or mottled by corrosion but not otherwise injured, may be as effectively ruined for commercial purposes as though the injury had gone deeper. These different factors will vary in relative importance with the particular application involved, and the endeavor was to cover all five.

Factors (3) and (4), indicated the use of tension test bars as salt-spray samples and also the use of duplicate test bars, kept in dry air, as control samples, to permit determining the loss of strength. This shape was accordingly selected.

The Tests

The rolled and forged alloy samples were obtained in sheet or bar form from the manufacturers. Alloys A to E, inclusive, were milled down to standard tension-test form for flat specimens, $^1/_2$ in. in width for A, B, and C, and $^3/_8$ in. for D and E over a gage length of 2 in.; Q was a round bar turned to a diameter of $^3/_8$ in. over the gage length. All of the other specimens were of the standard cast tensile-test-bar form turned to a diameter of 0.505 in. over 2 in. gage length, with threaded ends $^3/_4$ in. in diameter. All the cast bars were poured two in a mold with a central feeding hole, the metal flowing past risers which served as skimmers to both ends of each test bar. The bars were symmetrically placed about the feeding hole to insure as nearly as possible similar conditions for the two bars. One bar from each mold was used for the salt-spray test and the second one held as a control.

The bars were fed from both ends in order that the two streams might meet in the test section, so bringing out in the test any undesirable features which might develop at the junction. All of the bars of cast alloys currently in use by the General Electric Company were poured as part of regular production work by its aluminum foundry. Others, in use elsewhere, were poured by other foundries by request of the General Electric Company, also using regular foundry practice. A few alloys, added to complete the range of compositions, were specially mixed by the Research Laboratory of the company.

These test bars (two pairs each of alloys D, E, and W to AA, and four pairs of each of the others) were machined to size as already described. The round test bars were long enough to give $^1/_4$ in. to 1 in. length inside the threaded ends before coming to the section reduced in size. On this a flat face $^3/_8$ to $^1/_2$ in. wide by $^3/_4$ in. long was filed to give a measuring point for determining depth of corrosion and for determining Brinell and scleroscope hardness.

The bars for the salt-spray test were numbered, washed in benzol, and carefully weighed before placing in the salt-spray box. After 14 and 28 days they were again weighed. The mean gain in weight, in grams per square inch, is given in columns 2 and 3 of Table 3. The various bars of the same alloy showed surprisingly close agreement. At the end of eight weeks the bars of the sixteen alloys in the first series were all finally removed from the salt spray, arranged according to rate of corrosion as judged from their appearance, and photographed. This initial series served as a standard scale, and alloys later tested were given places in this same scale. (See column 6, Table 3, 1 here being the best and 16 the poorest.)

TABLE 2 RESULTS OF TENSILE TESTS

Alloy No.	Hardness, Brinell	Hardness, Scleroscope	Proportional limit, air, lb. per sq. in.	Ultimate Strength, Lb. per Sq. In., Air	Ultimate Strength, Lb. per Sq. In., Salt spray	Per cent loss	Modulus of elasticity, air, lb. per sq. in. × 10⁶	Reduction of Area, Air, per cent	Reduction of Area, Salt spray, per cent	Elongation in 2 Inches, Air, per cent	Elongation in 2 Inches, Salt spray, per cent
Initial Series											
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
A	36.1	12.2	8375	17340	17140	1.1	11.5	58.8	54.7	15.6	16.6
B	36.0	11.0	3910	18300	18110	1.0	11.7	55.4	49.2	26.2	26.3
C	52.6	16.0	5130	28760	27420	4.7	12.7	30.1	22.3	18.4	16.2
D	103.8	30.7	16700	54600	53050	2.8	10.6	29.2	24.9	21.6	20.0
E	58.9	18.3	14425	29840	28770	3.6	11.3	38.0	23.4	16.2	13.8
F	26.8	5.6	1300	13520	13320	1.5	10.2	25.0	25.8	24.0	22.8
G	75.6	19.7	9870	22480	17950	20.2	9.9	1.2	1.2	1.3	1.7
H	74.0	19.4	8730	24410	20150	17.5	9.6	1.6	1.0	1.7	1.7
I	37.3	13.4	5530	23040	20420	11.4	9.1	4.0	4.5	3.6	3.1
J	35.9	7.9	3240	17890	15210	15.0	7.7	8.1	6.9	7.0	6.4
K	43.7	10.1	3250	20310	19790	2.6	8.4	13.6	11.8	12.6	10.4
L	90.4	21.4	11070	28630	18530	35.3	8.9	1.2	1.6	0.7	0.5
M	105.5	28.4	17000	33250	24540	26.1	9.8	1.3	—	0.6	0.6
N	50.5	12.0	4330	21240	20240	4.7	9.4	3.4	5.0	3.6	4.8
O	103.8	28.3	19800	27020	24230	10.3	9.7	0.6	—	0.4	—
P	111.9	31.5	—	33300	27190	18.3	—	0.5	0.4	0.4	0.4
Second Series											
Q	101.3[1]		22500	50280	56820	—	10.2	6.7	4.9	5.2	5.0
R	67.8		9500	23300	20000	14.2	9.8	2.7	2.6	2.2	1.8
S	88.4		16800	37100	34030	8.3	9.3	4.9	5.4	4.6	5.5
T	90.3		21330	48175	42890	10.9	9.9	13.2	10.5	10.0	7.5
U	35.4	9.7	3150	15400	14300	7.1	9.9	5.6	4.9	5.4	3.5
V	40.0	10.5	3500	18045	17800	1.3	10.3	5.0	5.2	4.6	5.2
W	59.7	17.6	7500	24825	25800	—	9.6	5.6	5.5	5.2	6.0
X	48.8	18.2	3500	23360	22330	4.4	9.0	8.7	7.8	7.6	7.6
Y	90.3	29.8	15000	27670	25170	9.0	10.4	0.4	0.8	0.2	0.9
Z	48.0	15.2	5250	20400	18770	8.0	12.0	5.9	3.1	4.5	4.3
AA	78.4	29.9	22000	29000	28000	3.5	8.7	0.4	0.4	0.2	0.4

[1] Brinell hardness of salt-spray samples was 122.9.

TABLE 3 RELATIVE RATING OF ALLOYS TESTED BASED ON RESISTANCE TO SALT SPRAY

Alloy No.	Gain in Weight, Grams per Sq. In., 0–14 days	Gain in Weight, Grams per Sq. In., 14–28 days	Depth of Corrosion, Inches, Uniform	Depth of Corrosion, Inches, Bottom of pits	Relative Rating Based on Appearance	Relative Rating Based on Gain in weight	Relative Rating Based on Depth of corrosion	Relative Rating Based on Per cent loss of strength	Per cent loss in area to bottom of pits	Per cent loss of ultimate strength
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Initial Series										
A	0.0080	0.0022	0.001	0.001	2	2	3	2	1.2	1.1
B	0.0076	0.0025	0.001	not pitted	3	1	2	1	1.3	1.0
C	0.0160	0.0246	0.0026	0.0055	7	7	8	7	6.4	4.7
D	0.0118	0.0149	0.0015	0.002	5	5	4	5	2.1	2.8
E	0.0183	0.0158	0.0035	0.004	6	6	7	6	4.2	3.6
F	0.0086	—	0.001	not pitted	1	4	1	3	0.8	1.5
G	0.0648	0.0764	0.004	0.020	14	16	14	14	15.3	20.2
H	0.0486	0.0930	0.003	0.023	13	15	13	12	17.4	17.5
I	0.0388	0.0515	0.004	0.016	10	12	12	10	12.5	11.4
J	0.0317	0.0265	0.004	0.013	8	9	11	11	10.3	15.0
K	0.0086	0.0059	0.0012	0.0042	4	3	5	4	3.3	2.6
L	0.0669	0.0342	0.010	0.042	15	14	16	16	32.1	35.3
M	0.0620	0.0342	0.0057	0.038	16	13	15	15	27.2	26.1
N	0.0212	0.0235	0.001	0.007	9	8	6	8	5.5	4.7
O	0.0294	0.0424	0.0023	0.014	11	10	9	9	11.8	10.3
P	0.0343	0.0556	0.0023	0.016	12	11	10	13	12.4	18.3
Second Series										
Q	0.0597	0.0080	0.0023	0.0063	8.5	9.5	8	—	6.8	—
R	0.0603	0.0646	0.0016	0.0087	12	14.5	8.5	11	6.4	14.2
S	0.0489	0.0509	0.0020	0.0056	12	13.5	8	9	4.7	8.3
T	0.0438	0.0551	0.0022	0.0098	12	13.5	8	9.5	8.0	10.9
U	0.0405	0.0148	0	0.012	6.5	9	8	8.5	9.5	7.2
V	0.0240	0.0087	0.0012	0.0012	4.3	5.5	4	2.5	1.1	1.3
W	0.0042	0.0021	0	0.0004	1	1	2	1	0.3	—
X	0.0258	0.0122	0.0002	0.0013	7	7	3.5	6.5	1.0	4.4
Y	0.0383	0.0495	0.0004	0.0107	9.5	10.5	7.5	8.5	8.3	9.0
Z	0.0334	0.0250	0.0006	0.0094	9.3	9	7.5	8.5	7.2	8.0
AA	0.0268	0.0116	0.0007	0.0124	7	7.5	8	6	9.6	3.5

The flat gage sections already mentioned were then carefully cleaned from all white deposit and measured with micrometers. This measurement agreed very closely with similar measurements made before placing in the salt spray. This surface was then very carefully filed down to remove all darkened metal, so approximating the depth of uniform corrosion, and measured, and then again filed down to below the bottom of the pits. The mean results are given in columns 4 and 5 of Table 3. Brinell readings, using 500 kg. load, and scleroscope readings with magnifier hammer were next taken on these same areas and on the corresponding spots on the control samples. Salt-spray and control samples gave virtually the same results except in a few cases mentioned later on, and so only the average figures are given.

Complete tension tests were then made on these samples, using a Ewing extensometer to determine proportional limit and modulus of elasticity. The mean results are given in Table 2. Where only two pairs of bars of an alloy were available, both were tested, but with the other alloys one bar of the four in the salt-spray box was kept untouched as a permanent evidence of appearance.

Bases Used in Rating Corrosion

This gives four bases for rating corrosion: Appearance, gain in weight, depth of corrosion, and per cent loss of strength. The relative ratings for the sixteen alloys in the initial series on these four bases are given in columns 6 to 9 of Table 3. The close agreement between these various ratings, each worked out independently, is worth noticing. With several alloys, check runs have since been made to determine the reliability of the corrosion results. In each case the agreement between the two runs has been relatively close.

The "per cent loss of area to bottom of pits" was obtained by imagining that over the 2-in. gage length the metal was ineffective to a depth equal to the maximum depth of pits and computing the resultant per cent loss of area. This is given in column 10 of Table 3, and for comparison the per cent loss of ultimate strength is given in the following column. The close agreement between these two columns, coupled with the fact that Brinell and scleroscope readings were virtually the same for both air and salt spray, indicated that the loss in strength was a surface action, and was not caused by internal disintegration of the material.

On some of the specimens it was extremely difficult to know just when the filing had reached to the bottom of the pits. This may account for the discrepancies in alloys R, S, X, and AA. A second factor present with alloys susceptible to heat treatment was the seasoning effect of the warm salt-spray box and the drying oven. Alloy Q apparently had not been completely seasoned before testing, and this seasoning action resulted in an actual increase in strength and of hardness of the bars in the salt-spray box. It will be noticed that the reduction of area and the percentage of elongation is usually less with the salt-spray samples. This will naturally result from the roughening of the surface due to pitting. This may be slightly accentuated by the seasoning effect already mentioned.

The test figures obtained by the authors prove the fallacy of the idea sometimes advanced that the corrosion resistance of aluminum alloys is in some way related to the tensile strength, that is, that the high-tensile-strength alloys show higher resistance to corrosion than those of low tensile strength.

It will be noticed from the tables that the manganese and the silicon alloys with relatively low tensile strength have the highest resistance to corrosion of the cast-alloy class, whereas in the fabricated class the manganese sheets are about comparable to those of the duralumin class.

A few words of caution should go with these tables. The physical properties given are based on a limited number of test pieces and are therefore not truly representative of the range of properties met in actual production; they should not be considered the minima of production and can therefore not be used for general design.

Discussion

J. B. Johnson[1] submitted a written discussion subsequent to the meeting in which he stated that the corrosion of aluminum alloys had been investigated by the Engineering Division of the Air Service on account of the failure of these alloys in structural parts when exposed to the salt atmosphere at fields located near sea water, and the failure of aluminum parts in the fuel system which came in contact with condensed moisture. Water invariably collected in fuel tanks, carburetors, and pumps while standing in the hangars, and this water was a prolific source of corrosion. A typical analysis of a deposit removed from carburetor bowl showed a large percentage of aluminum oxide: namely, water, 78; alumina, 15.5; organic matter, 5.5; and iron, sulphides, chlorides, etc., 1 per cent.

[1] Chief Material Section, Air Service, McCook Field, Dayton, O. Mem. A.S.M.E.

An investigation which has been made on several of the casting alloys used by the Air Service indicated the relative rate of corrosion in different media. The method of determining the amount of corrosion by the gain in weight was found to be satisfactory. All of the alloys tested were cast in the Engineering Division foundry in the form of circular disks, $4^1/_4$ in. in diameter and $^1/_4$ in. thick, which were machined on one surface and thoroughly cleaned with benzol and alcohol. The opposite surface was given three coats of spar varnish. The specimens were dried at 100 deg. cent., for 48 hours, cooled, and then weighed prior to exposure. The disks were subjected to atmospheric exposure, distilled-water exposure, and exposure to a spray containing 10 per cent of sodium chloride.

The atmospheric exposure was made on an outdoor rack. The samples were brought indoors after each month's exposure, dried for 48 hours, and weighed. Care was exercised that the disks were only taken inside for weighing after two days of fair weather.

The salt-spray test was made in a box similar to that described in the attached paper and which conformed to the Bureau of Standards' specification. A 10 per cent solution of sodium chloride in distilled water was used as the corrosive medium. The disks were placed in the spray for eight hours; then the spray was stopped and the specimens were allowed to remain in the box over night. This same operation was repeated for six days, when the disks were removed, dried, and weighed.

The distilled-water exposure was made by covering the disks with 18 cc. of distilled water—which formed a continuous film—and exposing them to the atmosphere of a room at practically constant humidity. The disks were exposed in duplicate batches. One batch was dried in an electric oven at 105 deg. cent. after evaporation of the water film, and then a new film was applied. This was repeated six times. The other batch was not dried nor weighed between applications of the film, but consisted of applying six quantities of distilled water, each being applied immediately after the evaporation of the previous film.

The results of these tests were shown in Table 4. These results bore out in a general way the results as obtained by Messrs. Basch and Sayre. It was interesting to note that there was little difference in the rating of the alloys, irrespective of the corroding medium. As the result of the observations made in this test, Mr. Johnson considered that the use of a film of distilled water gave the most uniform results and was closely analagous to the corrosion obtained in service.

TABLE 4 RELATIVE RATING OF CAST ALUMINUM ALLOYS IN THEIR RESISTANCE TO CORROSION

Chemical Analysis			Gain in Weight in Milligrams												General Electric Tests	
			Atmospheric Exposure						Salt-Spray		Distilled Water Exposure					
Cu	Fe	Si	1 mo.	2 mo.	4 mo.	$5^1/_2$ mo.	Total	Rating	Exposure	Rating	Alternate Wet and Dry	Rating	Wet	Rating		Rating
0.30	0.57	6.17	2.5	0	0.5	0	3.0	1	50	1	19	2	6	1	V	5.5
1.47	0.58	0.37[1]							..		15	1	21.5	4	N	8
1.95	1.63	0.34[2]	34	15	7.5	None	56.5	4	500	5	64	5	39	8	I	12
3.15	0.31	0.18[3]	25	14	12	2	53	2	150	2	35	4	11	2	R	14.5
3.40	0.50	3.65	27	11	18	None	56	3	300	3	76	6	27.5	5		
4.25	0.65	0.36[4]							..		20	3	12	3	Y	10.5
8.75	1.07	0.46	39	60	80	6	185	6	800	6	134	8	32	7	H	15
9.35	0.61	0.35	32	39	40	None	111	5	460	4	115	7	28	6	L	14

[1] Also 0.84 Mn. [2] Also 10 Zn. [3] Also 0.75 Mg. [4] Also 1.24 Mg. and 1.49 Ni.

The column at the right of the table indicated the analyses which most nearly corresponded to those tested at the General Electric Company and the rating obtained by the investigators.

The silicon alloy was the most resistant, but was not entirely satisfactory, as it was a difficult alloy to machine. The low-copper-manganese alloy had good resistance to corrosion, but had a low proportional limit and its use was limited to low-stressed castings. The copper-magnesium-silicon alloy and the copper-magnesium-nickel alloy were satisfactory for high-stressed castings, and if heat treated would be found more resistant to corrosion than the "as cast" alloys tested in this investigation. The alloys containing zinc and the 8 and 10 per cent copper alloys corroded considerably. An increase in the iron content of the copper alloys increased their susceptibility to corrosion.

Discussing Mr. Gardner's paper on the corrosion, cleansing, and protection of aluminum alloys, presented at the same session, Mr. Johnson wrote that the results of various investigations made by the Engineering Division of the Air Service on coatings for duralumin sheet corroborated to a large extent the observations recorded in that paper. They had found that aluminum powder in a vehicle of spar varnish in the proportions of aluminum powder, 26 per cent, and spar varnish, 74 per cent, gave the best protection against atmospheric corrosion; and that any of the ordinary pigments, when used with oil as a vehicle, would not corrode the base metal.

It was their opinion that the problem of coating duralumin was the same as that for sheet steel, as they had found that satisfactory coatings could be obtained by using two coats of enamel or by using a primer and one coat of enamel. The pigments which had been used included carbonate, iron oxide, chrome orange, yellow ocher, lamp black, magnesium silicate, zinc oxide, ultramarine blue, aluminum powder, and calcium carbonate.

They believed that the superiority of the aluminum powder was largely inherent in the pigment itself and was not due to its being used in conjunction with the aluminum surface, as they had found that a pigmented dope, using aluminum powder, when applied to doped fabric surfaces, would outlast most of the ordinary mineral pigments. The color obtained in using aluminum powder was not always desirable, and they had recommended as a protective coating a primer consisting of 53 to 57 per cent pigment and 43 to 47 per cent liquid; the pigment to be natural iron oxide containing not less than 35 per cent of ferric oxide; the liquid to consist of 70 per cent spar varnish and 30 per cent drier (turpentine, volatile mineral spirits, or a mixture thereof). The primer coat to be followed by an air-drying enamel made up on spar varnish as a vehicle.

S. Tour[1] wrote that, having a particular application in view, namely the use of aluminum alloys on board ship, the authors had chosen the salt-spray test. In choosing the method of testing to be used in any study of corrosion-resisting properties, one was always confronted with questions as to the type of corrosion testing that should be adopted, the reagents or corroding medium that should be used, the necessary concentration of the solution, the temperature at which the test should be run, and last but not least, as to the meaning of the figures that would be obtained in the test. In connection with the work which the authors had reported the following questions presented themselves:

1 Had some other type of testing, such as a total-immersion test, been adopted, would the results have placed the alloys in the same relative order as to corrosion resistance?

2 Had an atmosphere of SO_2 been used in the salt-spray box so as to have simulated to some degree the conditions in industrial districts, would the results have placed the alloys in the same relative order as to corrosion resistance?

3 Would an increase in temperature at which the test was conducted act simply to increase the rate of corrosion, and was this increase the same in all the alloys under test or would a variation in temperature tend to change the relative order of corrosion resistance of the alloys?

4 What was the relative corrosion resistance of the alloys tested as compared to the materials now being used on ship board, such as admiralty metal or naval brass?

The asking of these questions was not meant in any way as a criticism of the very valuable work of the authors. It was unfortunate that thus far there had not been devised a method of corrosion testing of materials which would give something in more definite and adaptable units and which could be used to predict the approximate life or service which a material would give. Possibly the test reported by the authors was such a test. If so, then the next step upon the part of interested parties to use this same test on numerous other materials in order to compile a table showing the relative standing of these materials. One of the main difficulties which arose in any attempt to coördinate the work of in-

[1] Doehler Die Casting Co., Brooklyn, N. Y.

dependent laboratories on corrosion testing was the fact that the same method of testing was not employed in any two cases. Very often the same type of test was used, but each investigator had one or more little improvements or modifications of his own which changed the test. In the case of the salt-spray test of the authors, they, for apparently good reasons, had decided to run the test at 30 deg. cent., and to daily dry the specimens for one hour at 40 deg. cent. But were the results comparable to those obtained in a salt-spray test run at 25 deg. in which the specimens were not removed and dried daily?

The authors had not given very much information in regard to the representative nature of the specimens used. If additional specimens were made up of approximately the same compositions, would they give approximately the same results on a duplicate test? In other words, had enough samples of different runs been tested to show definitely that the variations in corrosion resistance were due to compositions and not to some other property of the metal such as porosity, grain size, impurities, etc.?

The results of tensile tests shown by the authors in Table 2 would in some cases indicate that possibly the specimens were not truly representative of regular commercial product of alloys of the compositions shown in Table 1. For instance, they obtained a die-cast test bar of 4 per cent copper and $^1/_2$ per cent magnesium with a tensile strength after heat treatment of 48,175 lb. per sq. in. while their "Y" alloy containing 4 per cent copper, 1.5 per cent magnesium, and 2 per cent nickel after heat treatment only had a tensile strength of 27,670 lb. per sq. in. Before the results obtained by the authors were therefore accepted as even a basis of evaluating the alloys of the general compositions tested, it should be known whether the same results were obtained on material produced from month to month and on materials produced at several different plants.

T. S. Fuller[1] wrote that the particular features of the test described in the paper which differed from those of the test set forth by the Bureau of Standards such as the use of a 3 to 4 per cent solution of sea instead of a much stronger one of table salt, the removal of the samples from the spray box once each day, and the pouring of test bars in duplicate, using one for the spray test and one as a control, were details which were quite essential in the work described, and which in the future might well be considered as possibilities for incorporation in a standard spray test.

The fact which stood out preëminently in the data collected by Messrs. Basch and Sayre was the superiority, with respect to their resistance to corrosion in the salt spray, of the alloys of aluminum and zinc over those of aluminum and copper. For example, samples Q and X, and AA, composed of aluminum and zinc, in Table 3, judged by each of the several criteria used by the authors, were all markedly superior to samples H, L, M, and other compositions of aluminum and copper.

A comparison of samples Q and I in the same table was significant. Q containing 7 per cent zinc, 1.25 per cent magnesium, and 2 per cent iron showed to a very considerable advantage over sample I which contained 8 per cent zinc, 3 per cent copper, and 1.3 per cent iron. The amount by which I was inferior to Q must necessarily indicate the deleterious effect of 3 per cent of copper upon the corrosion resistance of an aluminum alloy containing 7 to 8 per cent of zinc.

Jesse L. Jones[2] wrote that it was evident from the tests given, although the authors did not draw these conclusions, that none of the alloys of aluminum were very well suited to withstand salt-water corrosion; therefore the interest in methods of protecting these alloys from such corrosion should be very much stimulated. Considerable work was being done in various quarters on this subject, with more or less success. It was a well-known fact that aluminum and its alloys could be tinned by scratch brushing while submerging the articles under the molten metal. A protective coating of Wood's metal might be obtained in a similar manner. The Schoop process had been employed with more or less success recently to protect aluminum articles from salt-water corrosion by coating them with a spray of metallic cadmium, either by direct application with the Schoop gun or by use of that apparatus in connection with a revolving drum. This latter process was especially adapted to the coating of considerable quantities of very small articles.

[1] Research Laboratory, General Electric Co., Schenectady, N. Y.

[2] Metallurgist, Westinghouse Electric and Manufacturing Co., East Pittsburgh, Pa.

Robert J. Anderson,[1] in a written discussion, stated that aluminum alloys were often considered to be unsuitable for certain applications in engineering construction because they corroded. The facts in the case were that aluminum and its light alloys generally were actually more resistant to some types of corrosion, e.g., ordinary atmospheric corrosion, than were most steels, and, moreover, certain aluminum alloys were much more resistant to specific corroding media than were other aluminum alloys. The selection of definite aluminum alloys for corrosion resistance in specific applications could best be determined by actual tests, such as those carried out by the authors, and tests of this kind were very urgently needed by the aluminum industry.

It was of rather more than passing interest to draw attention to the corrosion resistance of manganese-containing aluminum alloys. As a rule, such alloys were more resistant to corrosion influences than correspondingly alloys without manganese, and the 98.5:1.5 aluminum-manganese alloy was more resistant to some corrosive media than was substantially pure aluminum. There seemed to be good possibilities for the development of special aluminum alloys which would be more resistant to corrosive media than the usual alloys, and the most promising elements to employ as additive metals in small amounts appeared to be chromium and manganese. The effect of chromium in rendering iron non-corrosive was well known, and it would be interesting to examine the effect of chromium on the corrosion resistance of aluminum and the ordinary aluminum alloys.

It might not be out of place, wrote Mr. Anderson, to direct the attention of the authors to the possibilities of the accelerated electrolytic-corrosion test as developed recently in the U. S. Bureau of Mines by G. M. Enos, J. R. Adams and himself.[2] This test could be applied to any metal or alloy, using any electrolyte as to corroding media, and yielded results, in a few hours, which were comparable to long-time immersion or service-corrosion data. It would be interesting and useful to check the results of the accelerated electrolytic corrosion test with the spray test.

Archibald Black[3] who opened the oral discussion, said that it was interesting to note in the authors' paper that tests had been made by immersing the samples in a solution of sea salt and distilled water instead of using the original sea water. That recalled results of some of the early navy tests on sheet aluminum and sheet duralumin, and showed the importance of the method of testing. In those tests the results were very misleading. The samples were rather radical in their performance; some were badly etched, and some were not hurt at all, and the only explanation was that such foreign matter as oil floating on the surface of the water greatly interfered with the accuracy of the tests.

F. B. Coyle[4] stated that the New York Navy Yard had been designated to investigate two aluminum-silicon alloys; one 8 per cent silicon and the other 13 per cent, and a good many castings made of that alloy had already been used and installed on the *Wyoming*. There was one large bedplate for a brine overboard pump that weighed 750 lb. that was made out of 13 per cent alloy, as well as some 8-in. gate valves. These valves weighed just one-third what manganese-bronze valves did, and were a marvelous achievement for naval use. In a twenty-day test with 20 per cent salt spray, the maximum pitting was 0.001 in., and there were but two or three small indications of pitting.

E. M. Hewlett[5] pointed out that the development of aluminum alloys was the result of a desire for lighter parts in instruments and also for the general reducing of the weight on board ship. The early applications of aluminum, however, were sometimes very disappointing. Therefore Mr. Basch had started this series of tests to find out what the differences were, why aluminum was good in one case and why it was not in another, and had found a certain

[1] Metallurgical Engineer, U. S. Bureau of Mines, Pittsburgh, Pa.

[2] Anderson, R. J., Enos, G. M., and Adams, J. R., Accelerated corrosion testing of metals and alloys in acid mine waters, Bull. 6, Coal-Mining Investigations Series, Carnegie Inst. of Technology, Pittsburgh, Pa.

[3] Consulting Engineer, Garden City, N. Y. Mem. A.S.M.E.

[4] Navy Department, Washington, D. C.

[5] General Electric Co., Schenectady, N. Y. Mem. A.S.M.E.

number of alloys that were very good indeed. There was one alloy that was very good, but on casting it would shrink at any change in dimension and crack at that point. The silicon alloy acted very much better in the foundry and gave equally as good protection against corrosion, and now the General Electric Co. had added aluminum to their list of alloys and put a very large amount of it in production. Aluminum was not a cure-all. Discretion must be used in selecting parts. The material was a little softer, a longer thread was needed and there were some cases in which it was not advisable to use aluminum; but there were a great many cases where it was, and besides there was the benefit obtained in the reduction of weight. This work had only been going on for about three or four years, and it would seem as though there would ultimately be available a very satisfactory list of aluminum alloys.

Ralph L. Goetzenberger[1] said that the development of suitable aluminum alloys was particularly important in connection with the design of optical instruments for army use. The Ordnance Department of the Army had been called upon to redesign binoculars for use in the service. They had had occasion to examine binoculars of almost every manufacture, both foreign and in this country, but did not feel that any of them were suitable, as far as lightness and resistance to corrosion were concerned. It was essential that the binoculars issued to soldiers should be light, and of course aluminum met this requirement to the best advantage.

In the matter of optical instruments the application of aluminum was particularly important from the point of view of corrosion or the powdering of the tubes. Corrosion material would collect on the surfaces of the lenses, and after a limited time, dependent upon the care in the manufacture of the product, would obstruct the vision through the instrument. Manufacturers both in this country and in foreign countries had attempted to cover the surfaces with some sort of resistant paint, but the introduction of a suitable corrosion-resisting aluminum alloy would be a great benefit to the service.

Lt. Alfred J. Lyon[2] said that the Engineering Division of the Air Service at McCook Field was also carrying on some development work in the light alloys, which included both aluminum alloys and magnesium-base alloys. Of the aluminum alloys, the silicon alloys had been attracting considerable attention in the last few years, and their greatest advantage, from the Air Service standpoint, was the ease with which they could be handled in the foundry, for as used as a cast alloy, small amounts of silicon in the more or less conventional copper alloys would greatly improve the casting properties. It had a disadvantage, however, in that it increased the machining difficulties, any alloy containing an appreciable amount of silica being very much more difficult to machine than the straight copper alloys.

On a recent investigation a comparison had been made of the physical properties of four more or less commercial alloys, one of the S.A.E. No. 12 type, one of duralumin type containing 4 per cent copper and 0.5 per cent magnesium, another which was a special alloy developed by McCook Field and consisted of 4 per cent copper and 3 per cent silicon, and alpax metal. These were cast in a crankcase weighing approximately 90 lb. and proportionate specimens were cut from different portions of this crankcase.

The most interesting results of this investigation were that the alpax metal, which was essentially a 13 per cent silicon-aluminum alloy, and the copper-silicon alloy had very low proportional limits compared to the duralumin-type alloy, which was heat treated, and the more or less standard 8 per cent copper-aluminum alloy. From that and from other information on these alloys it was concluded that the silicon had a tendency to lower the proportional limit and to increase the elongation.

There was no question, however, from the McCook Field tests, but that any alloy containing silicon was infinitely better from a corrosion standpoint. The Air Service had made recent tests and had carried on an investigation on the use of sodium silicate treatments for aluminum alloys, and were convinced that practically any alloy of aluminum could be effectively protected from corrosion, both from salt-water atmosphere and more or less ordinary conditions. They found that this particular method of treating aluminum alloys provided resistance to abrasion, also to breaking and bending. They had actually taken sheets around 0.030 in. thick, treated them in this way, and crinkled them up; put them in the salt-water spray, and they had stood up 100 hours without showing the least sign of attack at the point where it would naturally be expected that the surface had been broken.

[1] Ordnance Department U. S. Army, Philadelphia, Pa.

[2] Air Service U. S. A., Dayton, Ohio.

In regard to the manganese alloy, it was the experience of the Air Service that that alloy also had, especially in the cast condition, a very low proportional limit, and they were rather opposed to using materials with a low proportional limit due to the ease with which they deformed under load, so that they could not take advantage of the relatively high ultimate strength that was a characteristic of the manganese-aluminum alloys and also alpax metal.

L. Ochtman[1] called attention to the fact that the paper by Messrs. Basch and Sayre gave the resistance to corrosion of pure rolled aluminum sheet as being very much higher than that of the usual aluminum alloys, while Mr. Gardner's paper, Recent Observations Regarding the Corrosion, Cleansing and Protection of Aluminum, stated that pure aluminum would corrode much more rapidly than some of the aluminum alloys. This conflict of opinion, he believed, should be cleared up.

Ernest V. Pannell[2] said that the paper discussed was the first really serious attempt to present quantitative results of corrosion tests. There had been many tests made in the past which had depended on the loss-of-weight method, which, as the authors properly pointed out, was a very doubtful criterion on account of the impossibility of removing the net weight of the compound formed without abrading the sample.

However, the use of the increase-in-weight method brought also with it a little uncertainty, and in the paper it was mentioned that drying the samples for one hour at 40 deg. cent. would partially or completely dehydrate the compound formed by corrosion. A good deal of importance attached to the completeness of the dehydration, because of the difference in the molecular weight of the molecule of aluminum oxide and the molecule of aluminum hydrate. If the dehydration was only partially completed, and if the tests were to be truly comparative, the oxide should be entirely reduced to its anhydrous form or alternatively be measured as a hydrate.

The real significance of the results lay in column 8, Table 3, that was, the depth of corrosion, because with corrosive influences of considerable activity the metal was usually found to pit and perforate locally before a very significant weight increase would be noted over the whole sample. That would be found especially true of samples of sheet or those in which there was a relatively large area and small volume. There might be a hole through the sample before a very appreciable average rate of corrosion was observed.

The authors had pointed out quite logically that alloys of higher tensile strength were not necessarily more or less liable to corrosion, that corrosion depended upon other features; but there was a demonstrated fact, and that was that the amount of corrosion would be in some way dependent on the amount of cold work which the material had received. The best example of this had been presented by the German experimenters Hein and Bauer about nine years ago, in their tests on cold-rolled aluminum sheet. It had been found that annealing distinctly increased the corrosion resistance. Whether that fact could be used practically was not known, but it was worth investigation. As the authors had further pointed out, the corrosion resistance was very much influenced by the proportion of copper in the alloy, and it seemed as if in the alloying of aluminum there had been too close an adherence to preconceived ideas. One of these ideas was that copper was the logical hardener, and, developing from that point, magnesium, manganese, silicon, and other alloys had been added but always keeping copper present. If investigations were started on a line of alloys which should be reasonably resistant to corrosion, Mr. Pannell believed the authors would agree with him that copper ought to be absent and some other element substituted.

Mr. Basch, in closing the discussion, said that, in answer to Lieutenant Lyon's remarks, the addition of copper to silicon alloys had always looked very enticing to the authors, but they had had to give it up because even small percentages of copper added to the aluminum alloys would decrease the corrosion resistance to a very

[1] Ch. Engr., Jos. Van Blerck Eng. Corp., Plainfield, N. J. Assoc-Mem. A.S.M.E.

[2] New York City.

marked extent. It was true that silicon alloys of 5 per cent had relatively low proportional limits, the true proportional limit of the 5 per cent silicon alloy being around 3000 lb. The proportional limit of Dr. Pacz's alloy, the alpax alloy, was around 6000 lb. The silicon alloys, with from 2 to 3 per cent copper added, would bring the proportional limit only slightly above that figure, but they had felt that the other features which they had been compelled to sacrifice—primarily the resistance to salt-water corrosion—were of greater importance.

As to the machinability of silicon alloys, that of course would depend very largely on how the alloy was made. The greatest machining trouble experienced with silicon alloys was the so-called hard spots, which dulled the tools and caused tearing of the surface. These hard spots were generally traceable to oxide-coated silicon particles, caused either by faulty manufacture of the silicon or by faulty introduction of the silicon. Silicon oxidized at a relatively low temperature, below the melting point of the aluminum and if, in mixing the melt, silicon was thrown on the surface and allowed to stay there for any length of time or if it was preheated before adding, it would coat itself with a hard oxide which was not reduced during the subsequent melting operation and which entered the metal. If the silicon in mixing the melt was not added until the aluminum was thoroughly molten and was then pushed immediately below the surface so that it covered itself with a film of aluminum, these hard spots would not appear. In making the silicon, care should be taken to discard the tops of the ingots which were exposed to the open air and therefore tended to oxidize. Undissolved silicon in aluminum might also cause hard spots (iron silicides and silicon carbide), but this trouble might be obviated by the use of a pure grade of silicon containing a minimum amount of iron and carbon.

As to the protection of aluminum alloys by sodium silicate or any other method, this would be all right if one could always deal with a piece of apparatus that needed no machining, but since most of the pieces that his company had to turn out were machined to a very large extent, naturally this form of protection would not lend itself to their construction.

In answer to Mr. Tour's first question he would say that it was generally understood that the total-immersion test was not as positive as an alternate-exposure test, and that too much reliance should not be placed on the results from the former; if it gave different results, the test would be to blame rather than the material.

In regard to the second question, he would say that tests in SO_2 would not have been placed in the same relative order because metals were not equally resistant to different corroding agents, and an alloy that was very resistant to salt water might not be resistant to SO_2 fumes any more than it would be resistant to an alkaline or other corroding agent; at least, not in the same order.

As to Mr. Tour's third question, the authors had not found any great variation in the rating of the alloys within the commercial range of temperature, that was, ranging from room temperature, 23 deg. cent., up to about 40 or 50 deg. cent.

In answer to the fourth question, he would say that if one considered the surface condition of the metal, that was, the esthetic part, as the criterion, then naval brass probably would show up better then aluminum. If, on the other hand, the decrease in tensile strength and the change in the physical characteristics were taken as the criteria, then the best aluminum alloys were apt to show up even better than some of the high-class bronzes.

Regarding Mr. Tour's comments on the fact that it was unfortunate there had been no method of corrosion testing of materials devised which would give something in more definite and adaptable units and which could be used to predict the approximate life or service which a material would give—something showing the ratio between the life of the apparatus and the test itself—that, of course, was a fact known to every experimenter. No one had yet been able to find out how long an apparatus ought to be tested in order to simulate actual life conditions. On steels and irons a test of 168 hours, one week, was generally held to correspond to a life test, but no data were available on that point, and that was the reason the tests described had extended over eight weeks.

Mr. Tour's comments on the authors' "Y" alloy were easily met by the statement that the "Y" alloy was not die-cast, only sand-cast, and there was quite a difference between sand-cast "Y" alloy, heat treated, and die-cast; that was, in chilled molds and heat treated. The authors did not have any chilled castings of the "Y" alloy and therefore could not get the full physical properties that the "Y" alloy in chilled castings generally showed.

Regarding Mr. Anderson's statements on the addition of chrome and manganese, manganese in rolled alloy was a very fine thing. In a casting alloy, however, it was very hard to handle. A 2 per cent manganese alloy, the remainder aluminum, had excellent corrosion resistance, machined nicely, and had a good appearance, but the percentage of rejections in the foundry was abnormally high; it was very hard to make castings of varying cross-sections, for they would crack and warp.

As to the effect of chromium, this was being studied as the present time and Dr. Pacz was experimenting with small additions of chromium, in the neighborhood of about one-eighth of 1 per cent.

In order to forestall any misunderstanding, Mr. Basch stated that the authors wished to emphasize the point that in their opinion certain aluminum alloys in resistance to salt-water corrosion came in the class of the better brasses and bronzes rather than in the class of iron and steel and were suitable for use in apparatus exposed to salt-water atmosphere without requiring any protective coating.

To check up the effect of different alloying elements tests were being carried on, and it was expected that at a not very distant date a chance would offer itself to make the results public.

Manufacturing to Close Limits

(Continued from page 188)

The measuring means should be as direct as possible.

Even where direct and accurate means of measurement are available, close work is expensive and should be called for only where the expense is justified by the requirements.

Tolerances should be set only after a careful study of their necessity and their cost. If right, they should be adhered to; if not, they should be changed.

Cumulative tolerances should be avoided. In placing a tolerance figure on a drawing the draftsman should consider how it can be checked, the observational error of the measuring instrument, and the influences of tolerances on other related dimensions. Dimensions should read from fixed and accessible points.

Greater clearances usually permit greater tolerances. If both can be increased with safety, economy is bound to result, and in many cases the product may be actually improved thereby.

Coming as the author does from a shop whose business and reputation have been built on precision manufacturing, this doctrine may sound strange. Dirt has been defined as any matter out of place. How shall we describe precision out of place?

The Machine-Tool Export Problem

(Continued from page 185)

This is a matter of really serious importance to the individual machine-tool manufacturer. Statistics covering the year 1921 indicate that the average American machine-tool builder exported more than 20 per cent of his product, so that export business for the industry represents to a large extent the difference between prosperity and depression. There is reason to believe that at the present time the average American manufacturer of general-service tools and machine-shop accessories should export well in excess of this ratio, and those manufacturers who are falling behind this standard will find it very much to their advantage to arrange for a careful revision of their export methods. Fortunately, it is comparatively simple to do this as experience shows that products of this character are sold in these foreign countries through machinery dealers residing in their important cities. The sales problem narrows down to that of establishing contact with some machinery dealer in each city who will be prepared to handle distribution of the product, and while it is perfectly true that in many instances difficulty will be encountered in establishing such contacts, it is probably more than equally true that methods can be found that will yield results far better than have been secured heretofore.

Recent Observations Regarding the Corrosion, Cleansing, and Protection of Aluminum

By H. A. Gardner,[1] Washington, D. C.

Aluminum and its alloys, such as duralumin, in the form of sheets or castings are finding wide application in naval and aeronautical construction. The tendency of these metals to show rapid surface corrosion when not protected with coatings has been observed in many instances. Aluminum gas tanks have shown interior corrosion when water has found its way into the fuel, by condensation or otherwise, and the gelatinous precipitates of aluminum hydrate formed have been carried up through the pipes. Similar effects have been observed in carburetor bowls, and corrosion of fuel and water pumps has been noted. Rapid whitening and roughening of the surface have also been observed on uncoated duralumin sheets subjected to salt spray on small surface craft. Corrosion has also been observed when aluminum parts have been in contact with spruce or other wood. This was attributed to the presence of tannic acid or similar substances in the wood. It would appear, however, that the wood simply acts as a sponge, absorbing small quantities of salt water and holding it in contact with the metal.

Corrosion of the under side of handhole covers on pontoons has been observed, and the effect was attributed to the corrosive action of the moist air in the pontoons. It was apparent, however, that the under side of the handhole covers had not been varnished, whereas the outside, which was varnished, was in excellent condition.

Marked corrosion has recently been observed on the outer portion of seaplane gas tanks at areas in contact with the rawhide or leather straps underlying the wire supporting strips. It was suggested that tanning chemicals in the rawhide were responsible. While traces of chemicals might possibly have had some influence, it is believed that the main factor was the absorption of salt water by the leather, which kept it in contact with the metal. In such instances a band of waterproof oiled canvas, such as canvas belting, should be substituted for the leather.

The preservation of carburetor bowls is a problem that is now being worked on, and coatings that are insoluble in gasoline and alcohol are being developed. The development at McCook Field, Dayton, of a process of treating aluminum with sodium silicate and then baking, is noteworthy. Possibly an aluminum silicate is formed. At any rate the treatment apparently causes the metal to be very resistant to corrosion.

Experimental Investigations

While it will be noted from the experiments presented later that the use of two coats of spar varnish materially reduces corrosion, even under severe conditions of exposure, this process preferably should be recommended only where a clear coating is desired so that inspection of the metal may be made. Under most conditions a pigmented spar varnish should be used. Aluminum powder is especially adapted for the purpose. Aluminum wing enamel containing 15 per cent of aluminum powder (Navy Aeronautical Specification) may be used.

Another similar coating that has given good service for general work is:

Aluminum powder	8 ounces
Navy spar varnish	1 pint
Mineral spirits	2 gills

This paint, containing about 25 per cent of aluminum powder, is of good hiding power and dries rapidly to a firm film. It works more freely than that made on the present specifications. The use of two coats is suggested, in order to get the best results. The film formed is much more waterproof and resistant to wear than clear spar varnish.

In the past there has been some discussion as to the best method of painting large aluminum and duralumin sheets exposed to salt water. While it is true that basic pigments such as white lead, red lead, and zinc oxide may, in the presence of moisture, cause slight etching of the surface of the metal, no substantial action occurs when the pigments are in oil. Paints made of such pigments have proved very satisfactory in test. They are, however, of much greater weight than one made with aluminum powder, and for this reason the latter is suggested for aircraft.

In some preliminary tests recently made by the author, sheets of aluminum and of duralumin were suspended in glass vessels half filled with test solutions. The test specimens were held upright in the slotted cardboard covers of the vessels. About one-half of the metal was submerged in the solution, one-fourth was exposed to the damp air above the solution, and one-fourth was subjected to atmospheric exposure. These were placed out of doors for a period of four weeks and then examined. Comparatively little corrosion was observed on the metal exposed to the air or to the space over the solutions. Considerable corrosion, however, was observed on the submerged portions of the panels and especially just below the surface of the liquids where the air could come in direct contact with the metal. This effect would indicate that accelerated results could be obtained by alternately exposing metal test strips to the solution and to air. A procedure of this sort is usually employed in the well known salt-spray test for determining the corrosion of metals. The results of this series of tests are given in Table 1, which is accompanied by a photographic reproduction of the test pieces. (See Fig. 1.) It would appear from these tests that the presence of wood does not stimulate the corrosion of aluminum, its action being merely that of moisture retention as heretofore noted. Even tests with a relatively strong solution of tannic acid failed to show marked corrosion, the tannic acid acting rather as an inhibitor.

It is well known that pure aluminum will corrode much more rapidly than some of the alloys of aluminum. Alloys containing copper, silicon, and manganese may corrode relatively slowly, especially those containing up to 2 per cent of manganese. High-silicon alloys of aluminum are the most resistant of all. It would appear, however, that regardless of the type of aluminum or aluminum alloy used, a protective coating is advisable in order to secure the greatest resistance to exposure around salt water.

Cleansers for Aluminum Alloys

Aluminum fittings, castings, and motor parts sometimes become covered with oil, grease, and dried paint. For cleansing these, various compounds have been used. Dipping in tanks containing benzol or Navy dope solvent gives effective results in many cases, but there is danger in handling volatile, inflammable liquids in large amounts around shops. Dry compounds, made largely of a combination of caustic soda, borax, and soda ash, have been used. These are usually dissolved in hot water to a 5 per cent solution. Their effect is rapid, but they may etch the aluminum, since the latter is readily attacked by alkalis. The addition of 2 per cent or 3 per cent of a neutral soap paste to the same liquid has been proposed, and this apparently aids in the cleaning operation and materially decreases the corrosive effect of the alkalis. The metal is placed in a boiling solution for from 5 to 30 minutes, according to the size and amount of dirt and grease present on the metal. After removal, the metal is flushed with hot water and dried. Some tests made on greasy aluminum and duralumin, and also upon the same metals having adherent coatings of dried paint, were made. The results are shown in Fig. 2.

On large, dirty, greasy parts the above process is efficient. The author has no data, however, as to the effect of the boiling alkaline solutions upon the physical properties of the metal. Whether occlusion of hydrogen gas, if evolved, would cause brittleness, should be studied.

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It has recently been found that the addition of a small amount of sodium silicate will inhibit the corrosive tendency of alkaline solutions upon aluminum and aluminum alloys.[1] In the experiments referred to, 0.05 per cent of sodium silicate was added to aqueous solutions of caustic soda ranging from 0.05 per cent to 26 per cent in strength. Strips of aluminum and aluminum alloys were exposed in these solutions with and without the sodium silicate addition. The sodium silicate had a most marked effect in inhibiting the corrosion and solubility of the metal. When the caustic soda solution was not greater in concentration than 0.05 per cent or not less in concentration than $3^1/_2$ per cent, the solutions containing sodium silicate had substantially no effect upon the metal. Similar results were obtained when the same solutions were boiled with the metal. In the solutions in which the water glass was not used the metals were very rapidly destroyed, in some instances being entirely eaten away in a short period of time. The action of the soda solution as a cleansing agent would not, however, be affected by the sodium silicate.

The author would suggest a 5 per cent solution of caustic soda or soda ash, with the addition of not less than 0.05 per cent of sodium silicate, as a general cleansing agent for aluminum parts. The addition of a small amount of soap paste might aid.

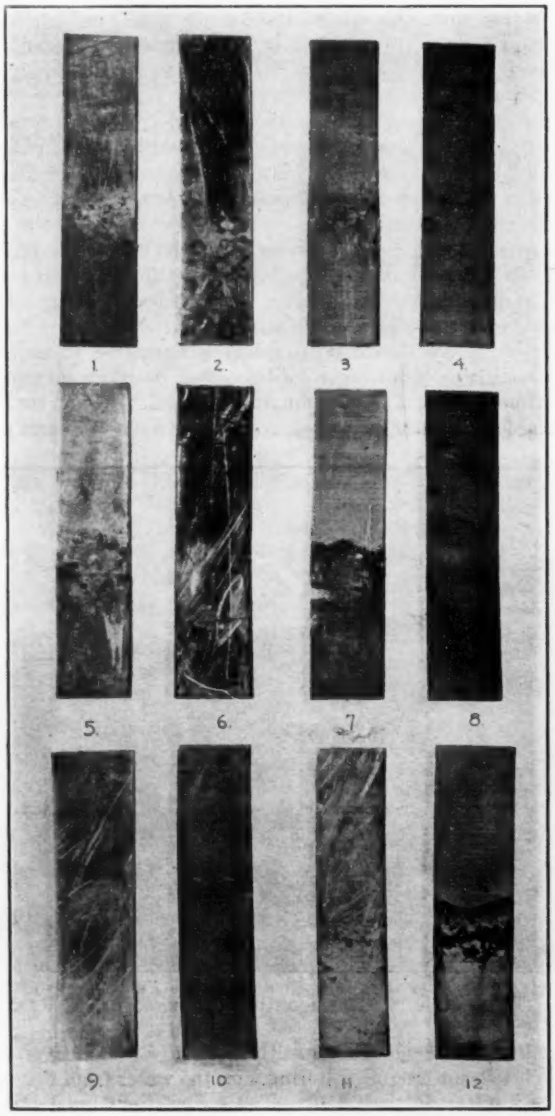

Fig. 1 Results of Corrosion Tests on Aluminum and Aluminum Alloys. See Table 1

[1] Ueber die Verminderung des Angriffs von Alkalilösungen aud Aluminum durch Zusatz von Wasserglas, by Röhrig. Communication from the Metallurgisch-metallographischen Laboratorium of the Erftwerk-Aktiengesellschaft, published in *Chemiker Zeitung*, 47, pp. 528–529 (June 21, 1923), referring to the work of Richard Seligman and Percy Williams (*Met. Ind.* London, 1922; *Chem. Zentr.*, 1923, II, 25).

TABLE 1 RESULTS OF CORROSION TESTS ON ALUMINUM AND ALUMINUM ALLOYS

1 ALUMINUM (SALT-WATER EXPOSURE). Badly etched. Thick covering of gelatinous aluminum hydrate on surface.

2 ALUMINUM WITH TWO COATS OF SPAR VARNISH (SALT-WATER EXPOSURE). Practically no corrosion except at spots near edge of panel where coating had become abraded.

3 DURALUMIN (SALT-WATER EXPOSURE). Lower part of submerged panel not greatly affected. Upper part, just below surface of water, very badly etched. Deep corrosion spots at localized areas were red in color, due, perhaps, to segregation of copper or manganese present. Some gelatinous aluminum hydrate surrounded these spots.

4 DURALUMIN WITH TWO COATS OF SPAR VARNISH (SALT-WATER EXPOSURE). Good condition with exception of two spots just under surface of water. These spots were similar in appearance to those noted in Test 3.

5 ALUMINUM (SALT-WATER AND SPRUCE-WOOD-SHAVINGS EXPOSURE). Considerable aluminum hydrate on exposed surface. Panels stained yellow over exposed surface but corrosion not bad.

6 ALUMINUM WITH TWO COATS SPAR VARNISH (SALT-WATER AND SPRUCE-WOOD-SHAVINGS EXPOSURE). Good condition. Very slight etching of surface on one side.

7 DURALUMIN (SALT-WATER AND SPRUCE-WOOD-SHAVINGS EXPOSURE). Considerable aluminum hydrate on metal, especially at points just below surface of water. Red spot at one localized area.

8 DURALUMIN WITH TWO COATS OF SPAR VARNISH (SALT-WATER AND SPRUCE-WOOD-SHAVINGS EXPOSURE). No corrosion except at two localized spots which were of red color.

9 ALUMINUM [ABSOLUTE ALCOHOL (30)—GASOLINE (70) MIXTURE]. No corrosion.

10 DURALUMIN [ABSOLUTE ALCOHOL (30)—GASOLINE (70) MIXTURE]. No corrosion.

11 ALUMINUM (5 PER CENT AQUEOUS-TANNIC-ACID EXPOSURE). Surface stained reddish yellow but not etched to any marked extent.

12 DURALUMIN (5 PER CENT AQUEOUS-TANNIC-ACID EXPOSURE). Brown stain on metal. Very slight etching just below surface of water at localized spots.

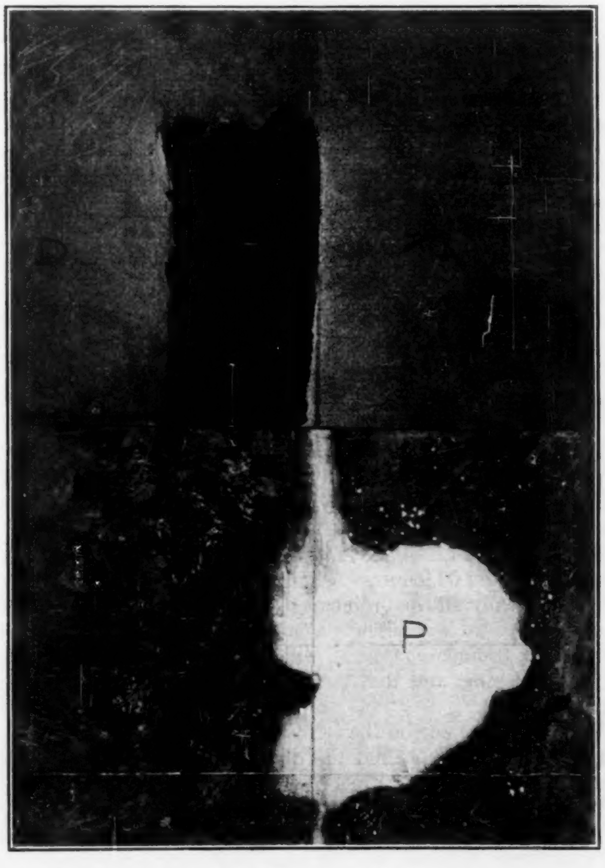

Fig. 2 Effect of Various Cleansing Agents on Aluminum with Grease and Paint Coatings

D—Effect of Navy dope solvent in efficiently removing old paint from duralumin.
A—Effect of caustic compound powder and soap paste in removing old paint from duralumin. A cleaner surface obtained in this manner. Slight etching noted.
S—Effect of soap paste when placed in contact with polished duralumin for 2 hours. No corrosion or etching noted.
P—Effect of caustic compound powder when wetted and placed in contact with polished duralumin for two hours. Considerable etching noted.

Aluminum production of the United States for 1923 exceeded the 1922 output, which was valued at $13,522,000, owing to the increased demand by makers of motor cars and utensils, and 500,000 long tons of bauxite were produced, which is equal to the largest annual production before the war.

Organization and Construction of Woolen Mills

Ideal Woolen-Mill Location Allows for Expansion, Has Good Railroad Facilities, Ample Soft-Water Supply and Near-By Mill Help

By A. W. BENOIT,[1] BOSTON, MASS.

THE intention of this paper is to deal with the organization and construction of small woolen mills; and with a view to determining the average size of such plants, a fairly complete canvass was made of the woolen mills of the United States, taking into consideration only those mills which were complete units, making their woolen yarn, and weaving and finishing the cloth. Where worsted, cotton, or silk yarns are used in the construction of woolen cloth, they are usually purchased from other mills.

Three hundred and eighty-two mills were listed, covering the entire country. The compiled figures give the following data:

Average number of sets of cards.....	9.4 per mill
Average number of broad looms.....	69 per mill
Location of mills:	
New England States..................	61 per cent
Middle Atlantic States...............	12 per cent
Southern States......................	10 per cent
North Central States.................	9 per cent
Pacific Coast States..................	8 per cent
	100 per cent

Massachusetts contains 36 per cent of the woolen mills of the New England States, and 22 per cent of those in the United States. Ninety per cent of the woolen mills in the United States do their own dyeing and finishing, and practically all produce their own power, either by water or steam, or by a combination of both. Seventy per cent of the woolen mills have one or more water wheel from which power is obtained for at least part of the year.

The range in size of mills tabulated, based on the number of looms, is from 2 to 280 looms. These divide into groups as follows:

From 2 to 25 looms.............	25 per cent
From 25 to 50 looms.............	20 per cent
From 50 to 75 looms.............	21 per cent
From 75 to 100 looms.............	11 per cent
From 100 to 280 looms.............	23 per cent

The above figures do not include mills making both worsted and woolen yarns, nor any doing only weaving and finishing, but they are complete enough to give a very good indication of the status of the woolen industry.

From the data given above, the average woolen mill contains 9.4 sets of cards and 69 looms. A mill of this size encounters and must solve practically all the problems of any woolen mill. For the sake of simplicity, we will discuss a mill with 10 sets of cards and 70 looms, and, to make it typical, will assume that it does its own dyeing and finishing, and that power is furnished by both steam and water.

To the average person the terms "woolen" and "worsted" bear no very definite meaning, and the distinction is very hazy. But to the textile engineer they are as different as cotton and worsted, and present to his mind two radically different sets of problems to be solved. They both use wool, it is true, but the grade of stock used, the machinery required, and the treatment for the two processes are very different.

The exact machinery to be used and the details of its construction will not be discussed here because such matters are usually settled by the owners, and the engineer is only concerned with the arrangement of the machinery, the buildings to house it, and the power to drive it.

The Site

If the plant is a new venture, the engineer is frequently called upon to pass upon the suitability of a site. An ideal site has sufficient land for the proposed plant with room for expansion, good railroad facilities for coal and raw stock, an ample supply of soft water for manufacturing and power purposes, and is near a good supply of mill help. The quantity of land, as a rule, presents no difficulty, and is a matter of dollars. Good railroad facilities are desirable, but not essential. Many woolen mills of the size under discussion are not on a railroad, but are able to truck all their coal and raw goods and still meet competition. As most of the finished goods are shipped in comparatively small lots, they must be trucked to the freight house in any case. The question of water is usually the governing feature, and there must be at least enough soft water available for boilers and manufacturing purposes. If it can be secured from a river with possibilities of damming so as to get a 25-ft. head, the operating conditions will be most favorable. If taken from a pond, it usually must be pumped. If no river or pond is available, the water may be secured from driven wells and pumped

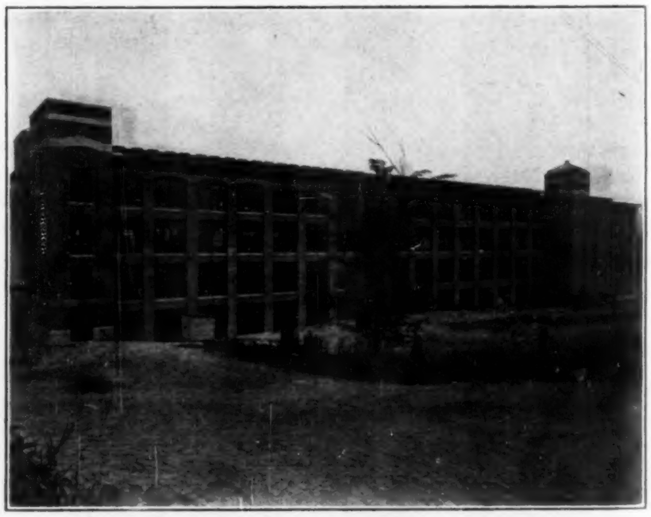

Fig. 1 Exterior of Woolen Mill

into tank storage. Quite frequently the water from a river or pond is so polluted as to require filtering, and the water from driven wells requires a softening treatment. These conditions must be considered when selecting the mill site. A good supply of trained help is necessary, but it need not necessarily be trained in the woolen industry. A small nucleus of trained woolen-mill help with good superintendence will soon assimilate the remainder of the help required. Most of the operations require only machine attendance without any expert knowledge, and only ordinary intelligence is required.

The Type of Buildings

Having selected the site, and with the size of the initial plant determined at, say, 10 sets of cards, the next question is the type of buildings. The engineer must keep in mind that the woolen industry is seasonal, and is affected by the wide variety of fancy woolen fabrics which in turn become popular from year to year and which the mill must be prepared to make. There is in consequence much rearrangement of machinery, with occasional additions of special machines. The buildings, therefore, must be flexible and the construction should allow for easy rearrangement of machines, shafting, piping, electric wiring, etc. The buildings of the greater part of the woolen mills of today are of the slow-burning mill-construction type, which seems to be the most satisfactory. Concrete buildings have been used some in recent years, but the spacing of columns which best fits woolen

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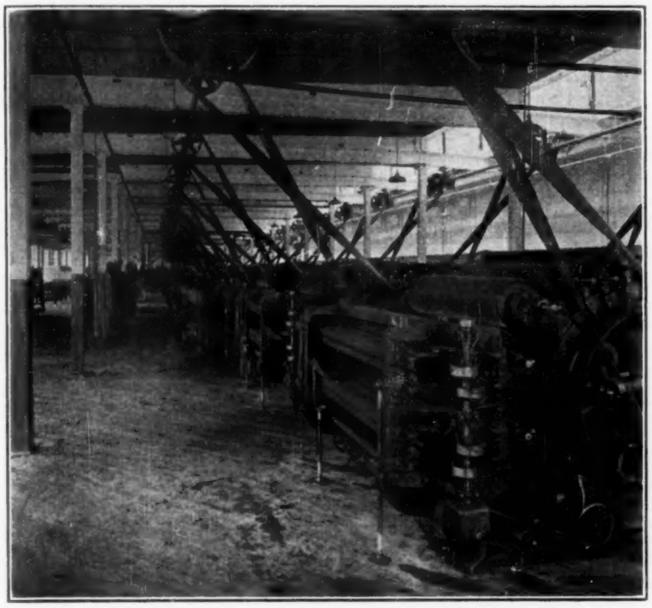

Fig. 2 The Card Room

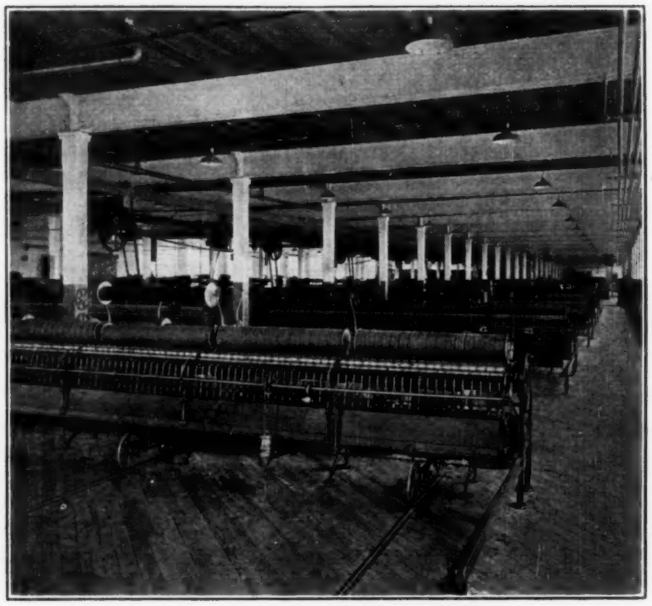

Fig. 3 Mule Spinning Room

machinery and the very light floor loads do not lend themselves to economical concrete design. The greater cost and the increased difficulty in arranging and rearranging machinery in concrete buildings of either the flat-slab or beam-and-girder type make them less desirable than those of slow-burning mill construction. The storehouse, however, can be of either slow-burning mill construction or reinforced concrete as circumstances may dictate.

A ten-set woolen mill is made up of the following departments, assuming that any reworked wool used is made elsewhere except the picking of the plant's own hard waste:

Raw storage	Carding
Wool scouring	Spinning
Wool drying	Warp preparation
Dye house	Weaving
Stock	Burling and mending
Piece	Wet finishing
Yarn	Dry finishing
Picking and blending	Finished goods storage

The machinery for each department is usually determined by the owner, and it is the problem of the engineer to organize it in its proper sequence for the most economical production and arrange each department properly. There must be ample working spaces around machines; those requiring good light must be located near windows; there must be the minimum amount of crossing of stock in process, and all precautions taken to reduce the number of hands and to make supervision easy.

Arrangement of the Departments

Preparatory to the machinery studies, which must precede the design of the buildings, an analysis is made of the departments. In the first place, such operations as wool scouring, dyeing, and wet finishing should be located on the ground floor, because of the amount of water used and the trenches required under the machines. The departments which are most closely related are also grouped, as follows:

Group 1 Raw stock	Group 4 Warp preparation
Group 2 Wool scouring	Weaving
Dye house	Burling and mending
Picking	Group 5 Wet finishing
Group 3 Carding	Dry finishing
Spinning	Finished goods storage

The raw stock is best located in a building by itself, built with low stories suitable for standing one bale or bag on end, large enough to hold about six months' supply, and within easy haul of the wool-scouring department.

In a ten-set mill the amount of scouring is not large because much of the stock purchased is scoured. Such materials as noils and shoddy require no scouring. One machine with its drier is usually sufficient, and it is located in the dye house. In this way stock which is scoured and is to be dyed at once is not dried, which saves time and expense. The combined dye house and scouring plant should be in a one-story building, having trenches under the machines and proper ventilation to keep the room clear of fog and steam. The construction best adapted to this purpose is a building with brick walls, wood roof, and a monitor. The dye house must be so located that the dyed stock, when dry, can be easily delivered to the picking department in bags or blown into storage bins. It must also be borne in mind that there will be some yarn dyed for the warp-preparing department and some piece goods for the wet finishing, and this work must be done without long hauls. All water piping in the dye house should be in the trenches with only covered steam piping overhead. Every precaution must be taken to prevent rust and scale from pipes, shafting, etc., dropping into the stock as it stands waiting on the truck.

The picking should have in connection with it a large storage space for colored wools. It is not uncommon to have over a hundred different grades and colors of stock on hand which must be kept separate and accessible, and to do this economically requires plenty of space. A ten-set mill would require, say, two mixing pickers, one burr picker, and a rag picker for hard waste. The

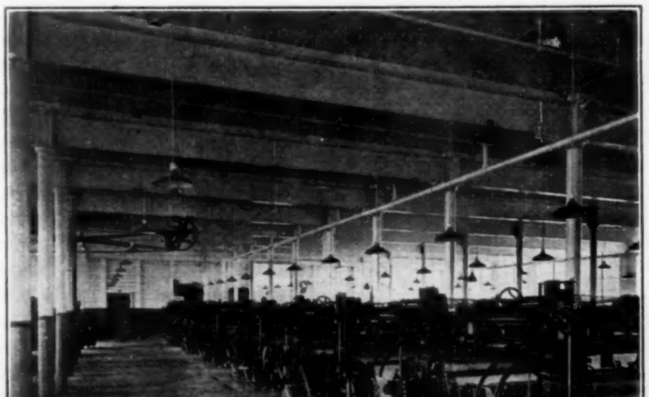

Fig. 4 The Weave Room

pickers should have at least 400 sq. ft. of floor space back of the feed to lay down lots. The two mixing pickers are usually arranged in tandem with stock bins between so that each lot can be mixed two or three times as required. There are many possible mixing arrangements, depending on conditions and the requirements of the plant. The picker house need not be a fireproof room, and is often located in the main building. The best and most economical method of handling stock from the picker room to the card room is by means of a blowing system, arranged to deliver stock to bins located back of the cards.

In designing the main mill, the carding, spinning, and weaving must be taken into consideration. The building must be wide enough to install across the room a 3-cylinder, 60 by 48 or 60 by 60 set of cards with a stock bin back of the feed. This means a building from 85 to 90 ft. wide, which is also wide enough to permit running the mules across the room. With mules across the room the spacing of columns should be about 12 ft., which again is suitable for the cards. The looms vary in width from 84 in. to over 100 in., depending upon the fabric to be woven. If they are to be placed in the main mill, as is usually the case, they should be set with the lay across the mill to get the best natural lighting. The spacing of the looms will vary from 7 ft. to 9 ft. center to center, depending on the required width of alleys. The span length from the wall to the columns should be long enough to take two looms, end to end, with a narrow alley at the wall. This span varies from 27 ft. to 29 ft. The main dimensions of the building having been determined, the machinery of the other departments can be arranged to the best advantage.

The weaving is sometimes placed in a separate sawtooth weave shed connected to the main mill. This increases the cost of the buildings, and is not usually justified.

The mending presents no particular difficulty, except that the light must be very good. This department is usually located near the windows, along one side of the building.

The wet finishing is a ground-floor operation because of the amount of water used and the trenches required under many of the machines. It must have a direct connection with the mending rooms by means of an elevator, chute, or conveyor. The machinery in this department is of great variety, but any of it will fit into the dimensions and column spacing determined for the main mill, if it is to be located on the first floor of that building. It is more common practice to put the finishing in a building by itself, however, using the first floor for wet finishing and the second floor for dry finishing. As in the dye house, all water piping should be below the floor in the machine trenches and only steam piping overhead.

The dry-finishing machinery is made up of a wide variety of isolated machines, around which there must be ample floor space for cloth-storage trucks, etc. If possible, there should be windows in the north side for final-inspection perches. The arrangement and operation of the machinery requires no special construction other than a good mill building. The finished goods are stored separate from the raw stock, and, since the amount is not large, a part of the finishing room serves for that purpose. The goods are packed and shipped from this department.

The Steam, Hot Water, and Power Problems

A ten-set woolen mill uses great quantities of water for manufacturing purposes, part of which must be warm. It also uses large quantities of both high- and low-pressure steam for process work. The high-pressure steam, usually at about 80 lb., is reduced from boiler pressure by reducing valves. The low-pressure steam can be from 5 to 15 lb., and is usually exhaust steam from the power unit. The hot water and low-pressure steam are part of the power-plant problem, and should be so treated.

The type of power plant which has been very successfully employed for mills of this size consists of horizontal-return tubular boilers with hand stokers and a 500-kw. turbo-generator arranged for steam extraction and operated condensing. A generator of this size has some excess capacity, but the power factor of a woolen mill is quite low and the additional capacity is required to take care of this difficulty.

The circulating water, after leaving the surface condenser, is used for manufacturing purposes, and the amount and temperature of the warm water required in the plant, and not the vacuum, govern the flow. This water should be delivered to the mill at about 120 deg. fahr. With a little experience the flow can be adjusted to give about this temperature under normal loads. Thermostatic controls have been installed, controlling the flow of water to the condenser, which have successfully maintained the desired temperature. The warm water is pumped into storage tanks supplying the wet finish, dye house, etc. The steam which is bled from the turbine supplies the low-pressure system and is used to boil kettles in the dye house, for wool scouring, for heating any water in excess of that furnished by the condenser, and in any place where low-pressure steam can be used. It has been used to dry stock, but to do this requires some changes in the machines ordinarily furnished, since they are piped for high-pressure steam. A reducing valve between the high- and low-pressure systems supplies any low-pressure steam required beyond that furnished by the turbine. The efficiency of plants with this arrangement is very high, and since the power is largely a by-product of the manufacturing steam, the power costs are low.

As stated before, 70 per cent of the woolen mills have some water power, but as a rule this power is available for only eight or nine months of the year and must be partly or wholly supplanted by steam power during the remainder of the time. The water wheels can be direct-connected or belted to a generator which is operated in phase with the main unit. These small water-wheel units are particularly valuable for driving a small night load or for furnishing power to the repair shops on Saturdays and Sundays.

The modern woolen mill is driven by a combination of individual and group motor drives. The tendency is toward a large proportion of individual drives and small groups. This has some advantages in the the way of flexibility, accident prevention, and cleaner rooms, but further lowers the power factor of the main unit.

Discussion

Warren B. Lewis[1] submitted a written discussion of Mr. Benoit's paper in which he said that it was interesting to note the locations of many of the small woolen mills throughout New England in out-of-the-way places and apparently as far removed from transportation facilities and the labor market as it was possible for them to be. These locations had been picked out originally almost wholly on account of the available water power, and yet water power was of little value to a well-balanced woolen mill, and today would be of the least consideration. Water in itself, for finishing purposes, was very important, but water power was of practically no importance. Power could now be a by-product of finishing, and the net cost per kilowatt-hour, including all fixed charges, labor and supplies could be well under 1 cent.

In a well-balanced mill not only could sufficient power be produced to operate the mill, but there would be enough to operate a very sizable additional industry if all of the steam which was used in the form of low-pressure steam first passed through a turbine.

To insure this result, however, finishing machinery would have to be designed and built with this end in view. Many finishing machines were heated with high-pressure steam, or, in boiling processes, equipped with pipes which were not sufficiently large for low-pressure steam. If dye kettles and other machines of a similar nature, driers, tenters, etc. were equipped with low-pressure coils and the heating system of the mill designed to operate on 1 or 2 lb. pressure, then the amount of steam required at any pressure above 10 lb. was very small; in fact, probably 75 or 80 per cent of all of the heat required for processes and for heating buildings could be in the form of steam at 10 lb. pressure or less.

It was questionable, therefore, whether there was any justification for spending money on water-power equipment in a well-balanced woolen mill.

It was improbable that any well-balanced woolen mill could afford to buy power at rates which prevailed at the present time. It should be possible to equip a new mill or reëquip an old mill so that the actual cost of power, as stated before, would be well under 1 cent per kilowatt-hour; and it was not likely that power could be bought at any such net rate.

[1] Cons. Engr., Providence, R. I. Mem. A.S.M.E.

The fundamental principles which should be the basis of woolen-mill design as far as power was concerned, might be stated thus:

1 Design the mechanical drives so that the least amount of power would be required.

2 Design the heating system, ventilating systems, dye kettles, driers, etc., so that low-pressure steam might be used exclusively.

3 Design the power plant to produce a kilowatt-hour at the lowest practicable steam rate consistent with the size of the plant.

4 Develop all power in one unit, even for power-plant auxiliaries.

With such a plant it would be found that power was entirely a by-product and live steam would probably have to be introduced into the low-pressure system, a condition much to be desired and one that would insure the minimum cost of power, light, heat, etc. per pound of wool worked.

James W. Cox, Jr.,[1] who opened the oral discussion, commended the paper as being an excellent exposition of the problems of the small woolen mill. He disagreed, however, with the author that a supply of soft water was a governing feature in locating a mill, for with apparatus now on the market hard water could be rendered soft at a very low cost. He felt also that in the case of mills running on low-priced fancy cloths it was important that they be located near large centers where it would not be difficult to hire such classes of skilled workmen as wool sorters, fine-woolen spinners, fancy weavers, and fine sewers for boiling and mending. The proper sorting of wool was essential where cloths were woven from very fine yarns and soft finished. Except on slow-running work he felt that women would not produce in as great quantities as men.

In regard to the departments making up a woolen mill, he believed that one for wool sorting should be included, as well as one for filling preparation. It was a saying that cloth was made in the sorting room. As to the engineer being concerned only with buildings, power, and the arrangement of machinery selected by the owner of a mill, he would say that there were engineers who not only did all that, but in addition utilized their broad acquaintance with various types of machinery, both domestic and foreign, in the selection of equipment for mills.

A. A. Adler[2] said that it was customary to believe that if a mill were fitted with large windows and many skylights, the light thus obtained cost nothing, but if the cost of a building thus equipped were figured out, it would be seen that a considerable amount was being paid for the light. It was now possible to employ artificial lighting and to control its effects much better than daylight could be controlled, and he believed that the time for large windows and sawtooth-roof construction was nearly past in many industries, and possibly in the textile industry.

L. H. Stark,[3] referring to the author's advocacy of the use of the extraction type of turbine in the power plant, asked whether there was not a limit to the amount of steam that could be extracted from such a turbine and yet obtain the full benefit from all of the steam that was coming from it. In the Middle West for about six months in the year the largest percentage of the exhaust steam was used for heating purposes; i.e., for a mill with a capacity of 1,000,000 cu. ft., practically 67,000 lb. of steam was required. It would therefore seem that a reciprocating engine would be a more efficient unit than the steam turbine.

George H. Perkins[4] contributed some interesting data in regard to the various mills dealt with by the author. Taking as a standard the 10-set mill, the coal required per set per year he found ranged from 125 to 150 tons, regardless of whether the plant was partly driven by water power or partly by purchased power or by power from any other source. He had two mills of the same size, one driven by water power and the other as the author advised, and the coal consumptions of the two were practically identical.

There had been a considerable increase in the power required per set owing to the increase in size of cards and their speed, and while in the older mills with straight mechanical drive there was oftentimes found one requiring not over 25 to 30 hp. per set, including all the machinery, the more modern types with larger cards ran as high as 35 to 40 hp. per set.

As to the water needed, figures he had obtained showed that about 25,000 gal. per week per set would supply all requirements of such a mill. As practically all of this water had to be heated to at least washing temperature, and some of it much higher, this would require in winter time half the coal that he had specified for such a mill.

The author, replying to Mr. Cox, said that in regard to the difficulty of training help, he had heard a large woolen manufacturer say that he could take a person of average intelligence and inside of three or four months make a skilled operator of him on most of his operations. During the war there had been a shortage of spinners and girls had been put into the spinning rooms and trained in a comparatively short time. One plant in the Middle West had reported that they did much more and better work than men.

In regard to Mr. Adler's remarks concerning mill lighting, he would say that as a rule the sawtooth-roof construction was neither justified nor necessary. It was possible to put the looms in the main mill, and the 60 to 70 per cent glass area there ordinarily gave ample daylight lighting for woolen mill work. For cloudy and short days each loom had a 100-watt lamp, and for every group of four looms there was an additional lamp hanging over the shuttle boxes.

Replying to Mr. Stark, he would say that the exhaust steam from a reciprocating engine was objectionable because of the oil in it, that from a turbine being much cleaner. As to the heating of a woolen mill, for the greater part of the day the heat generated by the machines was sufficient for that purpose, so that heating was required for the most part only at night and at week ends, and this did not synchronize with the power load. The greater part of the heating was done with live steam reduced.

[1] Textile Engr., New York, N. Y. Mem. A.S.M.E.
[2] New York, N. Y. Mem. A.S.M.E.
[3] National Knitting Co. Milwaukee, Wis.
[4] Consulting Engr., Boston, Mass. Mem. A.S.M.E.

Sweden and the Future Timber Supply

IN a recently issued pamphlet dealing with the iron and wood industries of Sweden, a few principles are stated which are of considerable significance to American engineers and industrialists. To quote from the publication in question:

The leading industries of Sweden are nowadays those based on the exploitation of the forests. The annual value of the products turned out by Swedish sawmills exceeds $400,000,000, and this value is steadily increasing as less wasteful processes of production are being introduced.

Until a short time ago the United States was a strong competitor in the Mediterranean trade, but the reckless cutting of timber, without replanting, has rapidly exhausted the supply available for export and turned that market over to Swedish dealers. During the last few years, however, a wonderful interest in reforestation of the denuded areas has developed in the United States, but it will take a century at least before American timber exportation once more can become a factor in the world market.

When the coal, the ores, and the oils of the world are exhausted, Mother Nature will still grow forests of magnificent quality on Swedish soil, and that is the reason why Sweden and its wood industries may confidently look foward to a bright and prosperous future, and why Sweden one day must become one of the most important factors in the world's trade.

Control of Raw Materials

SECRETARY Hoover pointed out in a recent letter to Senator Capper the urgent need for legislative control of foreign monopolies in imported raw materials essential to American industry. He wrote:

The last Congress made a special appropriation to the Department of Commerce to provide for investigation of imported raw materials essential to American industry which are under control of foreign combinations in restraint of price or distribution. While the reports upon this topic have not all been completed they will be ready at an early date and abundant material is in hand to prove unquestionably that foreign monopolies or combinations are potentially or actually in control of prices and distribution of the following commodities:

Sisal for binding twine is controlled through a combination of producers reinforced by legislative action of the Yucatan Government.

Nitrates and iodine are controlled through a British selling agency and reinforced by export duties in Chile.

Potash is controlled by combinations of German producers.

Crude rubber and gutta percha are controlled by partly legislative and partly voluntary combination of producers in British and Dutch Colonies.

Quinine is controlled by combination of Dutch producers.

Tin is controlled by combination of British producers.

Mercury is controlled by common selling agency of Spain and Austrian mines.

Coffee is controlled by the Government of Brazil.

Quebracho (for tanning purposes) is controlled by combination of producers and foreign manufacturers.

SURVEY OF ENGINEERING PROGRESS

A Review of Attainment in Mechanical Engineering and Related Fields

Straight-Line Water-Vapor Diagram for the Standard and High-Pressure Ranges

IN THERMODYNAMICS one usually has to deal with functions of three magnitudes, two of which vary independently of each other. Such functions may be represented graphically by means of either reticulated diagrams or nomograms. In the former, which are extensively used in thermodynamics, there corresponds to each state a point; in nomograms, a straight line.

There are a number of diagrams of the first type used in thermodynamics and in all of them only two of the most important variations of state, namely, pressure and volume, are expressed by straight lines, all the others being expressed by curved lines.

The author in a previous publication in German, Graphische Thermodynamik und Berechnen der Verbrennungsmaschinen und Turbinen, claims to have shown that in a logarithmic pressure-volume system all the technically important variations of state of gases can be expressed by straight lines, and now he states that by the same system of coördinates nearly all the changes of state of water vapor can likewise be expressed by straight lines. As the basis of his work the author uses the Callendar formula $\frac{I - 464}{101.5} = p(v - v')$ partly because it is well known in England, America, and Germany, and partly because the recently published Knoblauch steam tables give a surprising confirmation of the correctness of this formula.

The author then lists all the various formulas which determine the state of steam. While none of these are new, they are nevertheless reproduced here in order to render the remainder of the abstract understandable without reference to the original article. These formulas are as follows:

REGION OF SUPERHEAT

$$v - v' = 0.0047\frac{T}{p} - 0.075\left(\frac{273}{T}\right)^{\frac{10}{3}} \quad \text{.......... I (Temperature)}$$

$$\frac{I - 464}{101.5} = p(v - v') \quad \text{.......... II (Heat Content at Constant Pressure)}$$

$$\frac{U - 464}{78.1} = p(v - v') \quad \text{.......... IIa (Internal Energy)}$$

$$p(v - v')^{1.3} = \text{constant} \quad \text{.......... III (Adiabatic, Isentropic)}$$

SATURATION CURVE

$$p_s^{15/16}(v_s - v') = 1.7235 \quad \text{.......... IV}$$

REGION OF WET STEAM

$$(v_x - v') = x(v_s - v') \quad \text{.......... V (Volume)}$$

$$p^{15/16}(v_x - v') = 1.7235x \quad \text{.......... VI (Constant Steam Ratio)}$$

$$I_x = xI_s + (1 - x)t_x \quad \text{.......... VII (Heat Content)}$$

$$p(v_x - v')^{1.035 + 0.1x} = \text{constant} \quad \text{.......... VIII (Adiabatic)}$$

In these formulas the following notation is used: p, pressure in kg. per sq. cm.; v, steam volume in cu. m. per kg.; v', volume of liquid in cu. m. per kg.; T, absolute temperature; t, temperature in deg. cent.; I, heat content at constant pressure in kg-cal. per kg.; x, steam ratio in kg. of steam per kg. of mixture.

The system of coördinates is selected with $\log p$ and $\log (v - v')$ as the coördinates.

Isochors and Isobars. In this system of coördinates the variations of state at constant pressure (isobars) and at constant volume (isochors) are expressed by straight lines parallel to the axes of coördinates.

Throttling Line. At throttling the heat content I remains constant provided the pressure is constant. Formula II gives

$$\log p + \log (v - v') = \log \frac{I - 464}{101.5} \quad \text{.......... [1]}$$

In the case of a variation of state where the heat content I is constant, the right-hand member of the above equation must be also constant, which gives

$$\log p + \log (v - v') = \text{constant} \quad \text{.......... [1a]}$$

This equation corresponds to a straight line inclined at 45 deg. to the axes of coördinates. If there be given one point p_1, v_1 expressing the variation of state at constant I, all that is necessary is to draw through this point a line inclined 45 deg. to the axes of coördinates. Thus, if, for example, $I = 600$, then

$$\frac{I - 464}{101.5} = \frac{600 - 464}{101.5} = 1.34$$

In accordance with this equation the throttling line is drawn through a point at a distance of log 1.34 from the origin of the coördinates.

The variation of state at constant internal energy, as appears from Equation IIa, is also inclined at 45 deg. to the axes of coördinates.

Polytropic. The polytropic change of state expressed by

$$p(v - v')^n = \text{constant} \quad \text{.......... [2]}$$

is also represented by a straight line in the system of coördinates here selected. From this equation it follows that

$$\log p + n \log (v - v') = \log (\text{constant}) \quad \text{.......... [2a]}$$

This gives a curve which intersects the $\log p$ axis at a point where $\log p = \log (\text{constant})$, and the $\log (v - v')$ axis at a point where $\log (v - v') = \frac{\log (\text{constant})}{n}$. It is a line making with the $\log (v - v')$ axis an angle such that $\tan \alpha = n$.

Saturation Line. The saturation formula IV may also be expressed in the polytropic form:

$$\frac{15}{16} \log p + \log (v - v') = \log 1.7235 \quad \text{.......... [3]}$$

It intersects the $\log p$ axis at a distance log 1.9235 from the origin and makes with it an angle such that $\tan \beta = {}^{15}/_{16}$.

Line of Equal Steam Ratio. From Equation VI one can obtain the formula

$$\frac{15}{16} \log p + \log (v_x - v') = \log (1.7235x) \quad \text{.......... [4]}$$

from which it would appear that the variations of state at constant steam ratio occur parallel to the saturation curve. This line intersects the $\log p$ axis at a distance $\log (1.7235x)$ from the origin of the coördinates or at a distance $\log x$ from the point of inter-

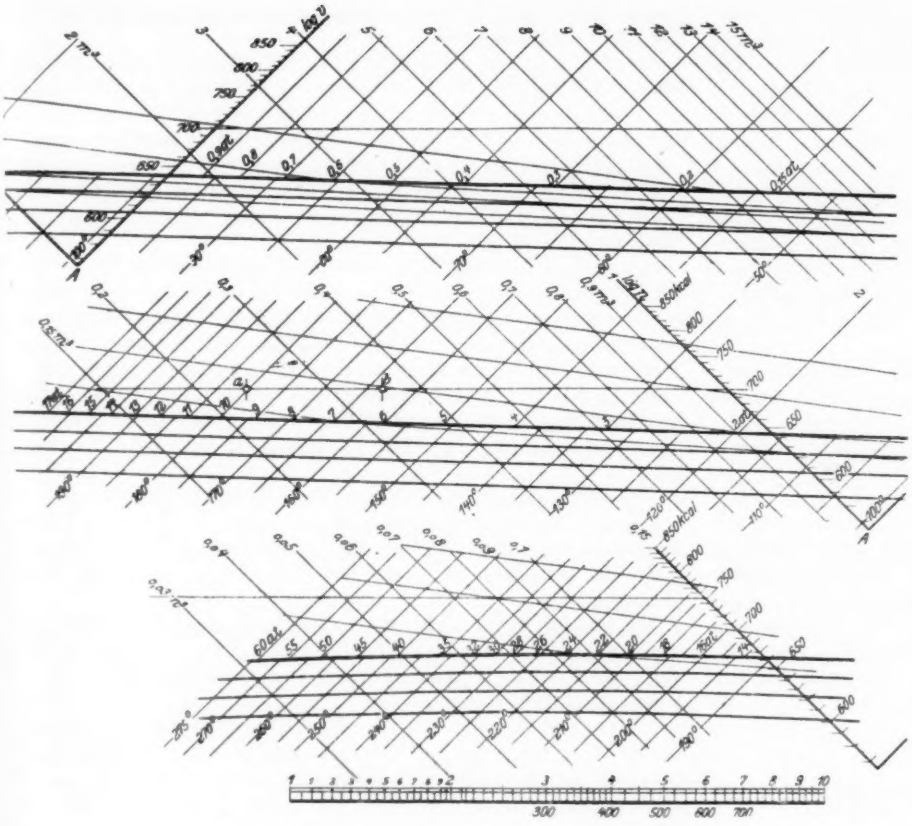

FIG. 1 NEW STRAIGHT-LINE WATER-VAPOR DIAGRAM

(This diagram is reproduced without change from the original article. Attention is called to the fact that where the period is used in decimal fractions in America and England, the comma is used in Germany, so that, for example, 0,9 at. means 0.9 atmos. in America; kcal = kilogram-calories; temperatures are either in deg. abs. or in deg. cent., depending on the formula, as shown in the notation used.)

section of the log p axis and the saturation line. If therefore the saturation line has been drawn, all that is necessary is to draw a line parallel to it at a distance log x therefrom.

Superheat Adiabatic Lines. Isentropics. Adiabatic variation of state in the region of superheat is represented in Equation III by a polytropic with the exponent $n = 1.3$. All these adiabatic lines are therefore straight lines inclined at an angle 52 deg. 30 min. (or more correctly, at an angle γ whose tangent = 1.3) to the log v axis. This adiabatic line is valid, however, only within the region of superheat, i.e., up to the point where it intersects with the saturation line.

To each adiabatic line there corresponds a constant value of entropy, so that the adiabatic line may be given a numerical figure representing the corresponding entropy. Since, furthermore

$$S = 1.1 \log T - 0.25 \log p - \sigma p - 1.0544 \ldots\ldots (\text{IX})$$

where

$$\sigma = 78.1 \frac{v}{T}$$

the adiabatic line intersects the log p axis at a point where

$$\frac{S + \sigma + 1.0544}{1.1} = \log T \ldots\ldots\ldots\ldots (\text{IX}a)$$

From this equation we can find the values of S_0 for any given value T_0. Furthermore from Equation I we can find the value of v_0 for the same value of T_0 and $p = 1$. By doing this we determine a point ($p = 1$, v_0) of the adiabatic line, having a given value of S and hence the isentropic line S_0.

Adiabatic Line for Wet Steam. In the region of wet steam, Equation VIII applies, which gives

$$\log p + (1.035 + 0.1x) \log (v - v') = \text{constant} \ldots\ldots [5]$$

This equation when x is constant corresponds to a straight line inclined to the log v axis at such an angle that $\tan \delta = 1.035 + 0.1x$. In the neighborhood of saturation $x = 1$, hence $\tan \delta = 1.035$. In the neighborhood of the steam ratio $x = 0.90$, $\tan \delta = 1.125$, etc.

The new diagram is shown in Fig. 1 and contains the following curves, all of the straight-line type:

In the Region of Superheat: 1, constant pressure p; 2, constant volume v; 3, constant heat content i; 4, constant internal energy U; 5, constant entropy S.

In the Region of Wet Steam: 1, constant pressure p; 2, constant volume v; 3 constant temperature T; 4 constant volume ratio x; and 5, constant entropy S; also the saturation line between the two regions ($x = 1$).

There are missing the isothermal lines in the region of superheat and the throttling lines in the region of wet steam, which is because they cannot be represented by straight lines in this system. The author shows, however, how these curves can be plotted. An additional auxiliary diagram is given in the original article indicating the values σ for use in computing the entropy. This is not reproduced here as it is merely a graphical presentation of a new Mollier table. For the sake of clearness only a few lines of each kind are drawn in Fig. 1. At the bottom a scale is given for p, v, x, and RT. The values of I are given at each stage on the axes of coördinates. (M. Seiliger in *Zeitschrift des Vereines deutscher Ingenieure*, vol. 68, no. 2, Jan. 12, 1924, pp. 25–27, *tA*)

Short Abstracts of the Month

AIR MACHINERY (See Power Plants)

The Selection of Motors for Driving Industrial Fans

IN THIS article, which deals chiefly with large fans including blowers and exhausters, it is stated that the power required to drive a given fan varies sharply with the speed, and that an overload or underload condition may easily result from voltage on direct current or cycles on alternating current being above or below normal.

For direct-current applications a compound-wound motor is more satisfactory than a shunt-wound motor, for the reason that its speed-load characteristic is of the opposite sign to that of a fan, thus counteracting in part the tendency to overload or underload with variations of voltage or air resistance. Direct-current fan motors may be controlled either by hand starters with proper equipment or by various kinds of automatic starters.

Variable-speed fans where direct current is available do not present a difficult problem. The shunt-field strength of the motor can be adjusted by a rheostat giving a motor-speed adjustment without material loss. However, the standard compound motor should not be called upon for more than 10 per cent speed increase by field control, and where a greater speed range is required armature control can be added to field control. Automatic speed regulators are available for holding pressure practically constant throughout a wide range of air resistance.

The squirrel-cage induction motor is well suited to constant-speed fan service. The speed is stable and constant under all loads and the motor itself is simple and reliable.

Squirrel-cage motors of smaller sizes are thrown directly on the line. For very large sizes compensators must be used; these may be hand operated or automatic. Synchronous motors are often

used for fan service in sizes above 40 hp. The fact that full load is attained with full speed makes it necessary to choose one of two ways to make the motor pull into synchronism. To do this a clutch may be interposed, which relieves the motor of load until synchronized. To pull the fan up to speed requires the clutch to dissipate, as heat, one-half the energy thus consumed. A new type, the supersynchronous motor, eliminates the clutch and is being successfully applied wherever the pull in load is more than 50 per cent of the full load (always the case with fans). This motor has a brake-held rotable frame which is released in starting. The frame is synchronized before the rotor and its attached load is started. The brake is then applied and, as the frame comes to rest, the rotor is brought up to synchronism with all its pull-out torque available for pulling the load into step.

The use of synchronous motors with their higher cost and necessary direct-current field excitation is justified where there is a group of induction motors in the plant giving a low power factor. Synchronous motors correct power factor and insure better rates if power is purchased, and, if plant power is used, make more generator and distribution capacity available for work.

Variable-speed fan operation with alternating current requires the use of either a wound-rotor induction motor, or a brush-shifting commutator type of alternating-current motor. The latter is more expensive but more efficient at low speed, which justifies its use where there is a great amount of slow-speed running. It is, however, less efficient at full speed than the wound-rotor motor. (R. H. Rogers, Industrial Engineering Department, General Electric Co., in *Chemical and Metallurgical Engineering*, vol. 30, no. 6, Feb. 11, 1924, pp. 231–233, 9 figs., *p*)

ENGINEERING MATERIALS (See also Testing and Measurements)

Comparative Tests of Hardness of Various Steel Tools at High Temperatures

THE author gives a brief review of previous work on the subject and then proceeds to the discussion of his own tests, which were all carried out at the works of Schneider & Co., Creusot, France, where he is chief engineer.

Three steels were used for these tests—

A, containing 1.390 per cent carbon
B, 1.330 carbon and 4.840 tungsten, and
C, 0.670 carbon, 18.530 tungsten, 3.923 chromium, and 1.040 vanadium.

The author describes briefly the heat treatment to which the steels were subjected previous to tests as well as the method of testing, the following being a summary of the results obtained (all temperatures in degrees centigrade).

Steel A. When heated the steel retains its original hardness (i.e., at room temperature) up to about 125 deg. The hardness then regularly decreases as a function of temperature up to 750 deg.

Plunging in water followed by oil tempering at 250 deg. during 15 min. does not materially change the cold hardness of the steel. The hot hardness seems at first for temperatures up to about 250 deg. a little less than for samples hardened without tempering, but the difference is small. The foregoing applies of course only to this particular steel having very high carbon content (1.390 per cent). The author has also tested another steel less hypereutectic, namely, one with a carbon content of 1.170 per cent, and obtained hardness curves considerably different from those for the A steel. From these tests it would appear that the higher the carbon content of a plain carbon steel, the better the steel is capable of maintaining its hardness at high temperatures. In actual figures, however, the difference is not large. The higher-carbon steels also seem to retain their hardness a little better after tempering.

Steel B. After hardening in water at 835 deg. cent., the B steel has a higher hardness than the A steel. It is also difficult to polish and often breaks during hardness tests. When heated its hardness begins to decrease at about 100 deg. It then remains constant up to 175 deg. and from then on decreases rapidly at first and then more slowly. The hardness of the B steel at high temperatures is greater than that of A steels, except for the temperature interval from 250 to 350 deg. cent.

Steel C. The initial hardness at room temperature of water-jet-cooled steels of this character is slightly less than that of A steels and considerably lower than that of B steels. The hardness of samples cooled in a lead bath is somewhat greater and more regular. At temperatures up to about 600 deg. cent. the hardness of steels treated by the Taylor process is better maintained than those treated by air jets, but from there on the curves have about the same appearance.

After tempering, the hardness of samples treated in air jets remains practically constant up to about 300 deg. cent., undergoes a slight reduction in the interval 400 to 500 deg. cent., and returns to its initial value at about 600 to 650 deg. cent. (secondary hardening), after which the hardness decreases rapidly.

In the case of samples hardened and tempered at 600 deg. cent. in a lead bath the variations of hardness between 0 and 650 deg. disappear and the hardness curve is very much more nearly horizontal.

The questions next discussed in the article are the influence of heat treatment on the hardness of high-speed tool steels at higher temperatures and also the correlation between the heat treatment and the structure of high-speed tool steels, including their hardness.

The conclusions at which the author arrives are that high-speed tool steels of the tungsten type, after hardening in water at 825 deg. cent., possess a hardness both at room temperature and at higher temperatures somewhat greater than the corresponding hardness of tungstenless carbon steels, and conserve it somewhat better than the latter after tempering; in other respects their behavior is not essentially different. (Jean Cohade in *Revue Universelle des Mines*, Series 7, vol. 1, no. 2, Jan. 15, 1924, pp. 75–104, 16 figs., *e*)

FOUNDRY

Reinforced Gray-Iron Castings

DESCRIPTION of a process that has been successfully employed for the manufacture of automobile-engine cylinders by a Belgian foundry.

Every foundryman who has had experience with casting automobile-engine cylinders knows how difficult it is to satisfy modern specifications which demand at the same time thin walls, intricate castings, and a leak-proof metal. In this case all the parts of the cylinder where porosity is frequent (valve seats, spark-plug ports, etc.) are provided with a thin steel wall which welds closely to the iron and insures perfect tightness. These walls are made of extra mild sheet steel which is given the proper shape before being introduced into the mold. The steel reinforcement (Fig. 1) is placed into the mold in such a manner that it welds to the exterior surface of the cylinder tube. The thickness of the reinforcing sheets has to be properly computed with due regard to the thickness of the cylinder walls in such a manner that the cast-iron mass will weld to the steel without absorbing it completely. In the last eighteen months a number of cylinders so cast have proved that by this process porosity may be completely eliminated.

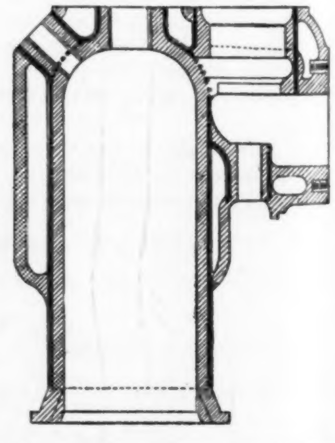

FIG. 1 MEYER METHOD OF CASTING REINFORCED CAST-IRON CYLINDERS

Because of the use of this method of preventing porosity in castings, it becomes possible to cast the cylinders in soft graphitic irons. The same process has been employed for making high-pressure gas and liquid containers. Abstracted from an article entitled La Fonte Armée, in *La Fonderie Moderne*, vol. 18, Jan., 1924, p. 16, 1 fig., *d*)

Reservoir on Cupola in Place of Mixing Ladle

DESCRIPTION of an adaptation of a cupola accessory well known in Europe. As installed in an American plant this device consists of a forehearth or reservoir with a capacity of approximately two tons. It has a 4-ft. brick-lined shell, mounted on a base plate supported by four legs, and equipped with a drop bottom similar to cupola and with a detachable cover lifted on and off by a chain block. The cupola is never stopped after it starts melting. A constant stream is allowed to flow into the reservoir and the latter is tapped and stopped to accommodate the ladles employed to convey the metal to the molds. (H. R. Simonds, in *The Foundry*, vol. 52, no. 3, Feb. 1, 1924, p. 87, 1 fig., *d*)

FUELS AND FIRING

Low-Temperature Processes of Coal Distillation

IN VIEW of the interest in this subject the following abstracts are presented from three publications.

The first deals with the Bergius process for liquefying coal. This is based on a report of experts who visited the inventor's factory at Mulheim-Rheinau in Germany. The works are said to be of commercial size.

According to the report the Bergius process can deal with the most diverse raw materials, such as petroleum residues, asphalt, bituminous schist, bitumens, tars, coal dust, etc. The general method adopted by Bergius consists in first preparing an artificial coal substance containing 85 to 88 per cent of carbon. This substance combines with hydrogen at very high temperatures and pressures, for example, 850 deg. fahr. and 3000 lb. per sq. in., the whole of the solid material being converted into a thick liquid which apparently has the same general complex composition as crude petroleum.

Natural coal in a pulverized condition at the above high temperatures and pressures also readily absorbs a large amount of hydrogen and is nearly all converted into a liquid material with a very high hydrogen content.

According to the report, in the plant inspected the hydrogen is produced by the so-called "Bamag" process based on the principle of decomposition of water by iron at a red heat. The hydrogen used need not be as pure as that required for the synthetic process.

Of the amount of hydrogen fixed, it may be said generally that the quantity depends on the length of time the hydrogen is in contact with the raw material and the composition of this material. In the industrial application of the process from 0.7 to 2.1 per cent of the hydrogen is fixed with the raw material.

Average results show yields from the industrial process as under:

A—Reducing the temperature of the vapor emerging from the dehydrating tube by 15 to 20 per cent, a complex liquid is obtained. This liquid, if obtained from otherwise useless petroleum residues by the Bergius process, has a boiling point of about 40 deg. cent.; if produced from tar, lignite, or coal the boiling point is about 60 deg. cent. The resulting liquid, which represents about 70 per cent of the total original quantity dealt with, may be split up by fractional distillation into (*a*) a light benzol at 150 deg. cent., which represents about one-third of the original volume; (*b*) a heavy benzol coming off between 150 and 210 deg. cent., and in quantity equal to about one-sixth of the original volume. This oil can be used as a fuel for large internal-combustion engines; (*c*) a product coming off between 210 and 300 deg. cent., representing about one-fifth of the original quantity. This liquid is suitable for Diesel and semi-Diesel engines; it also has the characteristics of refined petroleum.

B—Hydrocarbon gases, which analysis shows to be a mixture of methane, ethane, and propane. These gases, produced at the rate of 4200 to 7000 cu. ft. per metric ton of material treated, have a calorific value of about 12,000 cal. per cu. m. With this high calorific power the gases cannot be considered as a loss; they are, in fact, used for enriching the water gas which is added to coal gas for illuminating purposes. It is also sold, compressed in cylinders, for welding purposes, possessing the great advantage over acetylene of being perfectly stable. These gases are easily obtained in the liquid form.

Further heavy products are obtained similar to the Russian mazout, a residue which can be used either as a fuel oil or as a binder of high value. This residue is susceptible to still further treatment by the Bergius process. When tar is treated by the process a residue is obtained which is remarkably plastic and yields a pitch which is far superior to any obtained from the original material by ordinary distillation.

Among the findings of the Commission are the following statements. The Bergius process permits the production on a commercial scale of oils for which the country is at present dependent on foreign supplies. The raw materials used are those of which considerable quantities are found in the country. The application of the process in Belgium, therefore, becomes a matter of primary national importance. The process can furnish large quantities of home-produced benzol (about one-fifth of the consumption). It is especially desirable that the Belgian patents of the Bergius process should be retained for Belgians, so that in the event of war the country shall possess means for making its own benzol. (*The Iron and Coal Trades Review*, vol. 107, nos. 2900 and 2907, Sept. 28 and Nov. 16, 1923, pp. 471 and 735, *dA*)

A different process of low-temperature carbonization is that effected by the modified Mond producer as used by the Power Gas Corporation in England. As a matter of fact there are two types of this kind of by-product producer-gas plants, designated respectively as true-low-temperature and semi-low-temperature in accordance with whether the final gas temperature is considerably below the tar-evolution temperature of the fuel or approaches it.

Initially, in the Mond producer the temperature in the top section is seldom less than 1000 deg. fahr. As a result the coal is subjected to high-temperature carbonization as soon as it enters the retort, and the oils are cracked, with the resultant loss of the low-temperature oils. To prevent this it was decided to deepen the fuel bed considerably, retaining its usual width so that the entire charge is slowly gasified, low-temperature carbonization being effected at the top of the producer. The semi-low-temperature design is applied mainly to existing producers and at the present moment there are four large Mond gas plants being modified to work on this system.

The central fuel-feeding bell of the Mond producer has been replaced by a circumferential fuel feed. The latter arrangement is obtained by extending the mouth of the gas-outlet pipe to a position somewhat below the surface of the freshly charged fuel, the gas-outlet pipe being "luted" in the coal. Nearly all gas producers of the ordinary static type tend to burn more intensely at the edges, but when the gas-outlet pipe is arranged as shown all gas must pass through the center of the top of the fuel bed before leaving, thus insuring that the central fuel particles are heated up simultaneously with those particles that are nearer to the lining. As a matter of fact, the fuel temperatures in a by-product-recovery producer with central gas-outlet pipe across a horizontal plane just below the internal fuel (inverted) apex have been found to be practically even and vary, according to the load factor, between 480 and 840 deg. fahr. The time factor in the semi-low-temperature producer is from $^1/_2$ to 1 hr.

The advantages that have been proved as attendant upon this conversion are: Average daily gasification is increased by 50 per cent; the heating value of the gas is increased from 140 to 160 B.t.u. per cu. ft.; the carbon in the ash is reduced from 30 to 15 per cent; ammonia yield is unaltered, though steam consumption is nearly halved; the tar yield is increased by 30 to 40 per cent; the thermal efficiency of the process, aside from steam saving, is increased by 10 per cent; no superheating of the air blast is required, thus effecting an economy in maintenance charges.

The true-low-temperature plant is built along the same lines but is intended for new installations and not conversions. The main points of difference are that the time factor is longer, 3 to 4 hr., that the temperature at the top of the retort is reduced to 280 deg. fahr. to allow slower evolution of the volatiles and the minimum of cracking.

In the first commercial installation of the low-temperature plant there were 5.25 tons of coal per 24 hr. and the yields were as follows: 120,000 cu. ft. gas of 178 B.t.u. per cu. ft.; 20 gal. of tar; 90 lb. ammonia (56 per cent efficiency); the gasification efficiency, in-

cluding tar, was 91.5 per cent and excluding tar, 78.4 per cent. It is stated that the low-temperature plant can be installed today at about the same cost as the Mond plant under prewar conditions, and can be operated with from 10 to 30 per cent less labor, depending on the size of the installation, and can be accommodated on half the ground space. (C. H. S. Tupholme in *Chemical and Metallurgical Engineering*, vol. 30, no. 7, pp. 271–273, 2 figs., *d*)

In this connection it is desired to call attention to a paper on high- and low-temperature processes of coal distillation which, among other things, covers the commercial side of high- and low-temperature processes, including the coalite and carbocoal processes. It also gives some information on the process invented by Piron and Caracristi. In this process, which is said to be under test by the Ford Motor Co., the furnace consists essentially of a lead bath maintained at a temperature of about 580–600 deg. cent. by gas burned in cast-iron flues in the bath; the coal is carried in a thin layer on a series of cast-iron conveyors floating on the surface of the lead. On account of the intimate contact of the coal with the source of heat, the carbonization is very rapid, the coal remaining in the furnace only from 7 to 10 min., thus giving large capacity per furnace. In this type of furnace there is no danger of any degradation of vapors by contact with hotter surfaces, so it would appear to be a true low-temperature operation.

Another process is the Bussey, which has been developed to a semi-commercial stage in Louisville, Ky. It consists essentially of a vertical rectangular tapered shaft about 15 ft. high, equipped with a charging device at the top and a hopper below for receiving the coke. Air is admitted at the bottom and the resulting hot producer gas distills the raw coal in the upper part of the shaft. A water-cooled slice bar or movable grate slices off at intervals a portion of the coke or char into the hopper below, where it is quenched. The hot gases carry off the hydrocarbon vapors, which are collected in the usual manner. (Wm. Hutton Blauvelt in a paper presented before the New York Section of The American Society of Mechanical Engineers, December 18, 1923. Published in *Chemical Age*, vol. 32, no. 1, pp. 17–21, *gd*)

Motor Gasoline in the Winter of 1923-1924

The average motor gasoline being marketed this winter apparently possesses slightly better engine-starting qualities than that tested in former winter surveys, states the Department of the Interior, following the completion by the Bureau of Mines of the ninth semi-annual survey covering gasoline sold in ten American cities. The Department's conclusion as to this slight improvement in the starting power of gasoline now on the market is deduced from the slight decrease in the average for the initial boiling point of samples tested by the Bureau of Mines.

The results of the Bureau of Mines survey indicate that in certain districts petroleum refiners are obtaining a much better fractionation of the lighter products, or in other words are, through greater skill and improved mechanical appliances, able to make cleaner cuts of gasoline and kerosene refined from crude oil, thus permitting an increased yield of gasoline without appreciably affecting the quality. About two years ago the 90 per cent distillation point in Federal specifications was raised in order to permit a great quantity of gasoline to be obtained from a given quantity of crude oil, while still maintaining a motor fuel of satisfactory quality. At the time this change was made the end point in the distillation was allowed to remain as it had previously stood, and a question arose as to whether refiners would be able to take advantage of the increase in the 90 per cent point and still maintain the old end point. The results of the present survey indicate that this is being done successfully in certain districts.

With the exception of these indicated changes, the Bureau of Mines found that the winter grade of motor gasoline now being marketed is not materially changed from that of recent years.

The Bureau's ninth semi-annual motor-gasoline survey covered the cities of New York, Washington, Pittsburgh, Chicago, New Orleans, St. Louis, Denver, Salt Lake City, San Francisco, and Bartlesville, Okla. It was found that in all cities except St. Louis and Denver the average of all gasoline samples tested came well within the range of Federal specifications. Despite this fact, 74 out of the 149 samples tested, or practically one-half, failed to meet Government motor-gasoline specifications in some particular. The samples obtained in Washington, D. C., registered the fewest failures.

An appreciable decrease in the initial boiling point for the January, 1924, averages as compared with those for January, 1923, is shown, although this change is not so marked in the averages for New York, Pittsburgh, and Chicago. An interesting change has taken place in the averages for the 90 per cent distillation points of New York, Chicago, St. Louis, Denver, and Salt Lake City. The average 90 per cent point for New York has been increased 12 deg. and at the same time the end point average has actually been decreased by 1 deg. The average for the 90 per cent point in St. Louis has increased by 17 deg. while the average in the end point has only been increased by 4 deg. Denver and Salt Lake City, on the other hand, show an increase in the averages for the 90 per cent and end points, of 22 and 16 deg., respectively. (N. F. LeJeune,[1] I. H. Nelson,[2] and L. P. Calkins,[2] in *Survey Serial No. 2577, U. S. Bureau of Mines*, Washington, D. C., *g*)

GAS ENGINEERING (See Testing and Measurements)

INTERNAL-COMBUSTION ENGINEERING (See also Fuels and Firing)

The Gas Turbine

In the author's opinion, while many attempts have been made to realize the ideal of an internal-combustion turbine, it may be briefly stated that nearly all of them have been failures or somewhat akin to failures. In fact, from his own experience with internal-combustion engines, the author comes to the conclusion that he is not convinced that even with the best results which have been obtained the gas turbine can be made a commercial success.

A few years ago the author was determined to set aside the sum of about £20,000 as a fund to be used for research and experimenting in gas turbines. This sum of money has not been used for this purpose, as he is convinced that at present there are almost insuperable difficulties in obtaining sufficiently satisfactory results to warrant such an expenditure.

The problem of the gas turbine is much more difficult than many people believe. In addition to the prime-mover element consisting of a rotating wheel, nozzles, combustion chambers, ignition, and valve gear, there must be an air blower or air compressor capable of feeding the combustion chambers of the turbine with sufficient air at suitable pressures for carrying on the combustion processes. There must also be a similar blower or compressor for delivering gas in a suitable volume and at suitable pressure for mixing with the air. There must also be suitable motors, whether of the internal-combustion or other type, for driving these blowers, and to obtain the maximum heat efficiency there must be some apparatus for utilizing the heat of the exhaust gases in some of the processes connected with the gas turbine. From this brief inventory it will be seen how many problems have to be solved before a successful gas turbine can be built.

The difficulties that have been experienced so far as are known have been mainly metallurgical, in that a metal has not yet been found which possesses high tensile strength at high temperatures. Herr Holzwarth has patented a pure mild steel, unalloyed as far as possible, with a carbon content preferably below but not exceeding 0.1 per cent for his turbine wheels, and although there are no practical data to confirm this statement, one infers that with material of this kind some success has been obtained. When one considers that the turbine disk, nozzles, and blades have to withstand a temperature of about 2500 deg. fahr. and pressures reaching 300 lb. per sq. in., it will be understood that practically a new material has to be found which will maintain not only its strength but also its form under the temperatures and pressures mentioned.

It is quite true that similar difficulties were experienced in steam-turbine blades and disks and that they have been largely overcome, but the temperatures even with highly superheated steam are only about one-fourth to one-fifth of that which is experienced

[1] Asst. Petroleum Chemist, U. S. Bureau of Mines.
[2] Junior Chemists, U. S. Bureau of Mines.

in a gas turbine, so that the comparison is not quite a correct one.

The only gas turbine about which there has been any authentic information is that made by Hans Holzwarth. Sometime in 1923 the author found references in the German press to a gas turbine which was invented by Leich of Hamburg. He put himself in communication with the inventor and was told that six turbines of this type were actually at work in Germany. He asked for further information and for permission to visit Germany and see the turbines at work but this was refused, even if a German engineer were employed by the author to investigate the motor. The inventor agreed, however, to come to England and show the drawings to the author. He informed him that he had a gas turbine of 12,500 hp. working on blast-furnace gas in upper Silesia and that it had worked since July-August last, night and day, without a stop and that five other turbines had been built varying from 500 hp. up. The author expresses doubts as to the truth of these statements.

The Leich turbine, as shown in the drawings in the original paper, consists of a Laval rotor and nozzles combined with a labyrinth wheel and a great number of combustion chambers. The Holzwarth turbine has a maximum number of eight combustion chambers, whereas in the Leich turbine there may be as many as sixty combustion chambers round the circumference of the rotor according to the size of the machine.

The Leich turbine is constructed on the constant-pressure system, and in reply to queries as to whether there was any firing back when burning the explosive mixture, the author was informed that it had never occurred and that the labyrinth wheel prevented anything like that happening. The combustion chambers are extremely small in size, large ones not being necessary owing to the increased number of them, and on this form of construction Herr Leich places great importance.

Herr Leich informed the author that he guaranteed a thermal efficiency of not less than 36 per cent and that none of the turbines actually constructed gave less than 31 per cent. As the author could not be permitted either to enter into correspondence with the firms in Germany who were making the Leich turbine under license or to view any of the turbines said to have been constructed, he therefore declined all proposals made to him for manufacturing this machine, but as he has already indicated, there has been much newspaper publicity in Germany over this turbine, and as the way seems to be blocked for the ordinary engineer to make himself acquainted with what is going on, he repeats his suggestion that some of the enterprising engineering journals should find out the truth concerning this machine.

An illustration in the original articles shows a view of the Leich turbine. This is taken from a German magazine in which the turbine is described. A similar photograph was shown to the author by Herr Leich, and the former immediately said that the photograph was a faked one, which the inventor admitted was so, but he added the statement that it was purposely faked because he did not wish to show the whole of the construction of the turbine. (Hugh Campbell in a paper read Jan. 29, 1924, before the *Institute of Marine Engineers.* Abstracted from advance publication, *d*)

MACHINE PARTS (See Railroad Engineering)

MACHINE SHOP

The Plain-Head Turret Lathe as a Chucking Machine

A PRACTICAL article discussing methods of production of small chucking work on an ungeared capstan lathe, emphasizing the fact that on many castings machining can be done on an ungeared capstan lathe at much faster rates than on the heavier machines. He illustrates this by showing how various pieces can be handled on this type of lathe, among these being a case of machining two parallel holes in the end of a brass stamping. The next piece, the machining of which is described, is a small connecting rod for a motorcycle engine. Here the material is steel and the rod is in the form of a drop stamping. Both bores are machined at one setting, the jig plate being rotated about an eccentric center. The operation consists of start drilling, drilling large hole, second boring and facing boss, reaming large hole, drilling small hole and facing boss, and finally reaming small hole. The large hole has indents at either side, leaving about one-quarter inch of solid metal to be removed, while the small hole is machined from the slide. The production time for the rod is 4 min. complete. This method of dealing with connecting rods in quantity is somewhat unusual, but serves as a good illustration of what an ungeared capstan lathe can do when needed.

The next example is a small bevel-wheel blank made from an iron casting. In this case the article shows not only the piece machined (Fig. 2) but also the tool layout. The chuck is of the usual two-jaw self-centering type with specially formed jaws grip-

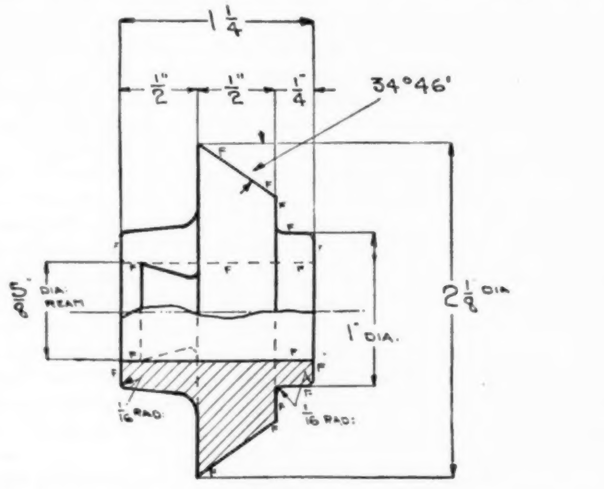

FIG. 2 SMALL CAST-IRON BEVEL WHEEL FOR MACHINING ON UNGEARED CAPSTAN LATHE

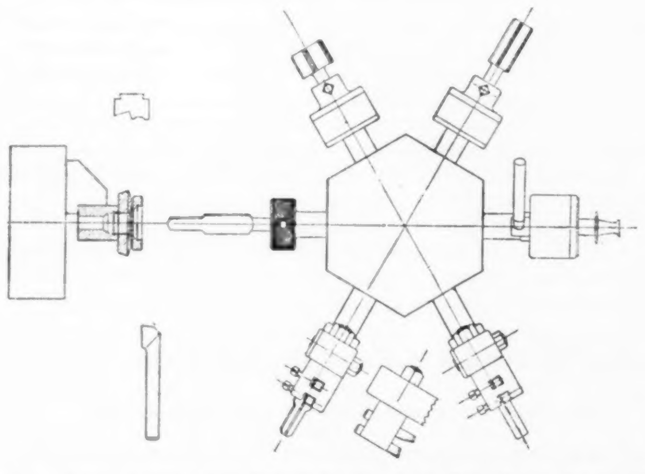

FIG. 3 TOOL LAYOUT FOR MAKING ALUMINUM TIME-FUSE BODY ON UNGEARED CAPSTAN LATHE

ping on the dovetail portion of the casting. For rough drilling and finishing the hole specially designed holders have to be used. Each of these carries two tools, one of which is set at the correct angle for the bevel, while the other is arranged to turn, face, and cut the radius on the corner of the 1-in.-diameter boss. Both the roughing and finishing blocks are provided with hardened and ground pilots, fitting the bore of the wheel, and great rigidity is obtained thereby.

The machining of the rear face is effected by an arrangement in which a rod carrying a facing cutter of the face-mill type, provided with a roller pilot end, is mounted in the spindle. This rod is provided with end movement by means of the handwheel shown at the end of the machine. The whole of the arrangement is carried by a bracket mounted on the end of the lathe body and is not rotatable, so that with the spindle rotating and the cutter stationary, end movement of the latter results in the face being machined. The face cutter is of course left-hand cutting. The end adjustment of the cutter rod is provided with stops so that accurate dimensions can be adhered to. The whole of the tool is carried on the turret except the rear facing device, and the cross-slide is not used.

The production time for the blank machined where marked *F* is $3^{1}/_{2}$ min. each. The next illustration (Fig. 3) shows a layout for a Ward $5^{1}/_{2}$-in. ungeared capstan lathe for dealing with a time-fuse body from an aluminum casting, and is part of a complete equipment recently supplied to an overseas arsenal. The rough casting of the article under consideration is stepped in two parallel diameters without a core and there is therefore a large amount of material to be removed. The cutting speed is approximately 250 ft. per min. on the external diameter, this being reduced to about 75 ft. per min. for final forming and tapping. The casting is gripped in a three-jaw self-centering chuck with stepped jaws, so that each one is automatically set to length when it is placed in the chuck by hand. The first operation consists of facing the end with the tool shown on the front of the cross-slide. After facing, the hole is rough bored with a two-step flat drill. Owing to the nature of the material, the cut has to be relieved for chip clearance two or three times during the operation. Following the rough drilling a combination tool consisting of a second boring bit and a knee tool holder with two tools. The front cutting tool in the knee tool holder deals with the largest diameter of the casting, while the second one rough turns the ultimate threaded diameter. The next turret station carried a similar combination for finishing the bore and removing further material from the external diameters. Next in order is a rack-recessing tool holder carrying a double recessing tool for producing the undercuts at the bottom of each threaded bore. Two releasing tap holders, each with a suitable tap, complete the turret layout, and the final machining operation consists of forming the large diameters with a vertical forming tool carried in a suitable holder located on the rear of the cross-slide.

It may appear to the average capstan-lathe user that some of the tooling is superfluous, but the piece must be produced on a repetition basis to fine limits. Readers who have had experience in this class of production will, however, appreciate the necessity of leaving the smallest possible amount of material for the final finishing tools to remove, so that they will stand up to their work without question for the longest possible time. The production time for the foregoing operations is 3 min.

To assist in the manufacture of this piece, the large external thread is produced on a thread-milling machine after all other machining operations are finished, thereby leaving this accurately finished diameter for subsequent chucking.

It will be noted that this diameter is used as a chucking piece while the second lathe process is effected. (E. W. Field in *British Machine Tool Engineering*, vol. 3, no. 25, Jan.-Feb., 1924, pp. 3–7, 9 figs., *pd*)

MACHINE TOOLS (See also Machine Shop)

Bed Design of the Buckman $8^{1}/_{2}$-in. Center Lathe

A DISTINGUISHING feature of the new Buckman lathe (of British manufacture) is the novel construction of the bed. This (Fig. 4) is a box-section member $20^{5}/_{8}$ in. in depth by $16^{3}/_{8}$ in. in width over the shears, the latter combining a series of flat and V-shape bedded surfaces for the saddle and tailstock members. The system of carrying the very deep and rigidly braced box section practically from end to end of the body is, however, its distinctive feature. The bed is supported at its ends on short box feet which are surmounted by shallow trays draining into the main tray suspended between the feet from the under side of the bed cross-ribs. The sump embodied in the main tray extends toward the back of the machine in a manner which is said to facilitate the removal of swarf.

The feed gear box, which is bolted to the bed in front of the headstock, carries both the guide screw and the sliding and surfacing feed shaft. The screw is fitted with ball thrust bearings at each side of the right-hand bearing bracket, and is used for screw cutting only; it is corrected on a special machine fitted with a lead screw certified by the National Physical Laboratory, Teddington. Drive to both the screw and the feed shaft is taken from the end of the spindle through a reversing gear quadrant and gearing, a nest of gears embodied in the gear box, which are operated through the medium of a sliding key and hand lever, supplying four rates of automatic traverse, varying from 14 to 112 cuts per inch, to the saddle. Change wheels are also provided for driving the guide screw in the correct ratio to the spindle for all standard Whitworth screw pitches.

The saddle apron is a very compact unit. The whole of the driving gears are supported on journal bearings. Sliding and surfacing feeds are derived from the gear-box shaft, thence through a drop worm meshing with a worm wheel. This wheel is carried on an eccentric stud by a sleeve carrying two small spur gears. By moving the handle through 90 deg. in either direction,

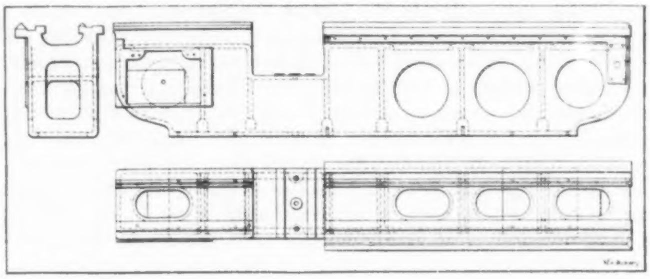

FIG. 4 DETAILS OF BED OF THE BUCKMAN LATHE

to the right or left, the position of the eccentric is varied to such an extent that drive is transmitted from the sleeve gears either through a gear for operating the rack-and-pinion sliding mechanism or through another gear to the cross sliding motion. The screw-cutting motion is engaged by moving two half-nuts in a vertical slide through the medium of a hand lever. [*Machinery* (London), vol. 23, nos. 585 and 590, Dec. 13, 1923 and Jan. 17, 1924, pp. 348–349 and 511–512, 4 figs., *d*]

The Whirling of Shafts

THE paper here abstracted is an attempt to explain the phenomenon of whirling by proving that it is essentially a case of vibration and obeys the laws of vibration, especially those relating to the phase change between the disturbing force and the resulting displacement.

In this connection the authors point out that the critical speed, which is the speed above which the system tends to rotate about its center of mass, is also the number of oscillations per second at which the shaft would vibrate if plucked like a violin string. The authors claim that this gives the clue to the correct explanation of the facts of whirling. For imagine the above shaft not to revolve but to be subjected to a periodic disturbing force of gradually increasing frequency. At frequencies much below the natural frequency of the shaft, these disturbing forces would produce little effect; this would be so until the frequency of the disturbing force nearly equaled that of the system composed of the shaft and its attached mass. When the two frequencies were equal, the amplitude of the motion of the mass *M* would increase until, if there were no friction, sufficient energy at that frequency would be stored up to break the shaft, or otherwise until the resulting friction absorbed all the available energy.

If, however, the frequency of the disturbing force were still further increased, the amplitude would gradually decrease until, when the force had a frequency many times that of the shaft, the latter would again be practically at rest.

This description leaves out of account some other facts, such as change of phase between the disturbing force and the motion produced, which the authors proceed to discuss.

While acknowledging that the critical speed of whirling is usually calculated by the same expressions as those which give the natural time of vibration, it is maintained that the identity of the two phenomena is not sufficiently recognized. To prove this, the case of the spring-controlled governor is cited, which, according to the ordinary treatment of whirling, i.e., equating the centrifugal and the elastic restoring forces, should come in again before a certain speed.

The authors have made certain experiments with a view to verifying the theories put forth, and these are described in the original article. Among other things they discuss the possible critical condition which occurs when a shaft is rotating at 71 per

cent of the true whirling speed, but claim that their experiments show that no such additional critical speed exists. They believe that the reason for this is that resonance can only occur if there is a disturbing force acting at right angles to the restoring force, and this is only the case at the speed for true whirling. At all other speeds, including that particularly under discussion, the line of action has a fixed and different orientation to the disturbing force, appropriate to the speed, and it is only at the true speed of whirling that this angle has a value of 90 deg. and consequently only at this speed that the conditions are critical.

A bibliography of the subject is appended to the original paper. (Julius Frith and F. Buckingham in *The Journal of The Institution of Electrical Engineers*, vol. 62, no. 325, January, 1924, pp. 107–113, 8 figs., *et*)

POWER-PLANT ENGINEERING

The Hickman Air Separator

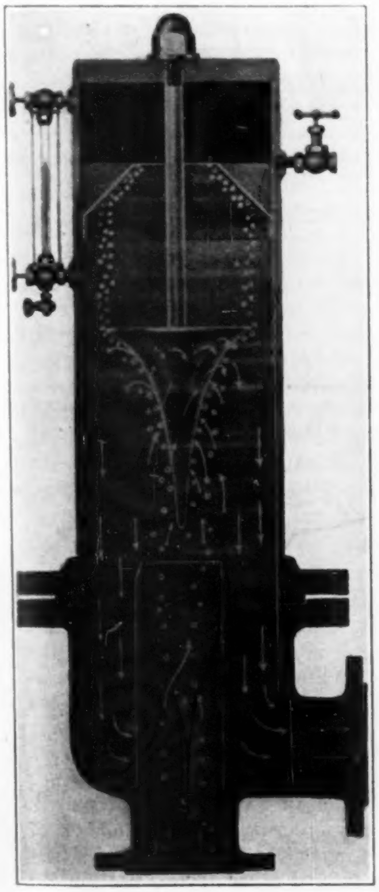

Fig. 5 Hickman Air Separator

Description of a device for the mechanical separation of entrained air from feedwater in steel plants, developed by the Hickman Air Separator Company, of San Francisco, Cal.

Referring to Fig. 5, the water entering the separator at the bottom passes at line velocity through a series of spiral deflectors which impart to it a centrifugal motion. In this condition of whirl it strikes an inverted conical baffle along the surface of which the bubbles rise to the air space above, where they are vented to the atmosphere, the water meanwhile passing down around the outside of the entering pipe and out of the feed line.

On July 14, 1923, a test was made at sea on the separator installed on the steamer *Maui*. The air vent was connected to a copper coil arranged for water cooling, and with the coil vented into an inverted graduated bottle the mouth of which was submerged. The following interesting results were obtained:

Time, start of test	3.08 p.m.
Time, finish of test	11.08 p.m.
Duration of test, hr	8
Hourly amount of feedwater, lb., total	128,700
Raw water, make-up feed, lb. per hr	1,250
Temperature of hotwell, deg. fahr	125
Temperature of feedwater, deg. fahr	238
Hourly volume of air separated, cu. in	100

The vented air displaced the water in the graduated bottle in a continuous stream of bubbles.

It is said that a number of such separators have been installed on various American ships, representing more than 75,000 hp. in boiler capacity. (*Western Machinery World*, vol. 15, no. 1, Jan., 1924, p. 42, 1 fig., *d*)

High-Pressure Steam in Germany

The Verein deutscher Ingenieure recently devoted a special session to the discussion of the subject of high-pressure steam, by which term is meant steam at a pressure in excess of 50 atmos. Some of the papers and discussions presented were published in the last issue of their journal for 1923, from which the following data are abstracted.

One of the important papers dealt with the present status of high-pressure steam in power-plant operation in various countries. The most interesting part of this paper to American engineers is that dealing with the use of high-pressure steam in Germany.

Contrary to the somewhat general impression prevailing in this country, it would appear that the Germans are proceeding in this matter in a very cautious and leisurely manner. Up to a very recent date 32 atmos. boiler pressure seemed to have been to all practical purposes the limit of commercial operation, and, for example, it was this pressure that was adopted by the Bavarian Dye Works in their recent installation. It was only quite recently that the Borsig Locomotive Co. at Berlin-Tegel risked the installation of a 60-atmos. pressure boiler [superheat of 430 to 450 deg. cent. (774 to 810 deg. fahr.)]. This is built under the Schmidt patents. The boiler is of the inclined-tube type as shown in Fig. 6 and the drums are made in one piece by welding. The use of such an element in construction would permit raising the operating pressure to as high as 100 atmos. Because of the great wall thickness of the drums, it is necessary to protect them in the first pass against the direct action of the hot gases. This is done in the present case by placing a non-conducting wall in front of the upper drum in such a way as to make the installation of the tubes easily possible.

Because of the use of this heat insulation, the walls of the steam drum cannot exceed the saturation temperature of the steam, or 275 deg. cent. (527 deg. fahr.). Such a temperature is not dangerous from an operating point of view, provided heat stresses are avoided by the use of a proper design.

As a matter of fact the first Schmidt boiler built for a pressure of 60 atmos. was in actual service for close to 15,000 hr. and tests have shown that the strength of the material was barely affected, which proves baseless the objection that the material would be rapidly weakened by the temperatures encountered in high-pressure steam generation. In this connection it is of interest to point out that the boiler materials were tested not only at room temperatures but also at 265 deg. cent. (509 deg. fahr.), which is approximately the temperature they are exposed to under steam pressure. It was found that at this temperature the tensile strength was improved but the elongation reduced.

The heads of the drums in the boiler under consideration were welded to the shells. Notwithstanding, however, the great care exercised in welding, there is a material reduction of strength of the joint at the high temperatures, so that in the future it will be necessary to avoid the use of welded drums, unless, of course, a way is found to produce welded joints that are not weakened by high temperatures.

It is significant that as a result of observations on the operation of the Schmidt boiler, the dimensions of the drums in the new Borsig boiler were reduced. The author believes that the diameter of 800 mm. (32 in.) for such drums is justified. The superheater in the Borsig boiler, like that in the original Schmidt experimental boiler, is arranged in two stages. It is located in the flue-gas zone of low temperature and is therefore not endangered, even with the high superheat temperatures used. In the stage first exposed to the gases the superheater is arranged in direct-countercurrent manner, so that the hottest gases do not impinge on the hottest of the superheater coils. In order to obtain sufficient heat transmission, however, great attention was paid to the regulation of velocity and proper baffling of the gases.

As is evident from Fig. 6, considerable attention was given to the subject of water circulation in the boiler. There can be two water circuits—one in the front part of the boiler by itself, and then again through the second nest of tubes. The steam is taken through a water separator from the second upper drum in which the water level is only little affected because of the comparatively small amount of steam generated.

Back of the high-pressure boiler there is installed for purposes of feed-water preheating a low-pressure boiler operating at 2 atmos. pressure, one purpose of which is to reduce the temperature of the flue gases as much as possible and also to avoid the difficulties encountered with soft steel or wrought-iron flue-gas economizers. The low-pressure steam developed is used for heating purposes.

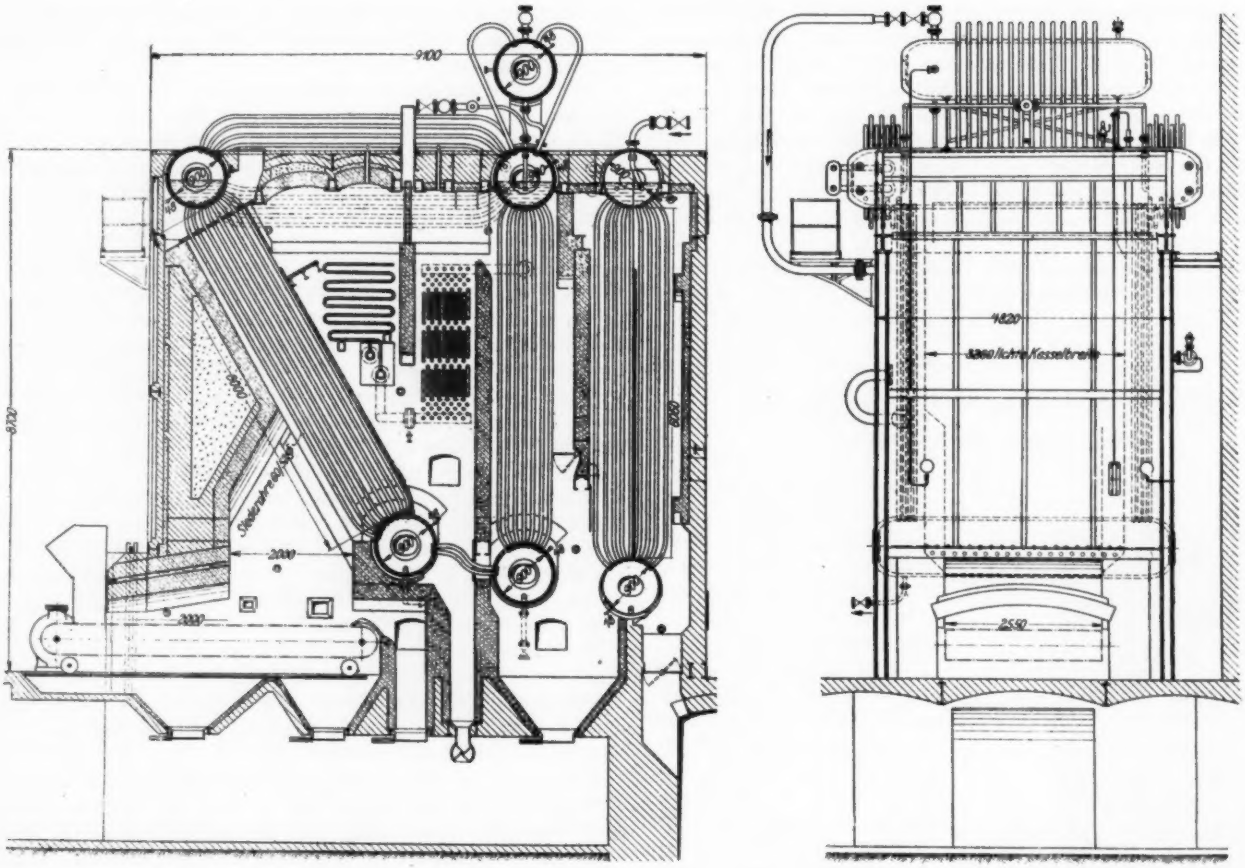

Fig. 6 The 60-Atmos. Pressure Borsig-Schmidt Boiler with Superheater and 2-Atmos. Low-Pressure Boiler
(*Siederohre* 60/52 = Tubes 60/52 mm. diameter; *Lichte Kesselbreite* = Width inside boiler.)

The output of the boiler under regular operation is estimated at about 7000 kg. (15,400 lb.) per hr. The evaporation per unit area of heating surface has been chosen at a comparatively low figure in order to make the water content of the boiler fairly large. This latter is in fact 16 cu. m. (565 cu. ft.), corresponding to 12,225 kg. (26,950 lb.) of hot water. In the Borsig installation the frequent corrosion troubles encountered where soft-steel flue-gas economizers are used, have been obviated by the installation of a low-pressure boiler. It is stated, however, that cast-iron economizers may also be used with high-pressure steam boilers. (O. H. Hartmann in *Zeitschrift des Vereines deutscher Ingenieure*, vol. 67, no. 52, Dec. 29, 1923, pp. 1145–1152, 9 figs., *dg*)

RAILROAD ENGINEERING

Locomotive Orders and Types in 1923

Statistical data covering both domestic and export business. The most interesting feature is that of dealing with the tendencies in design.

For freight traffic the 2-8-2 continues to be the general standard, with a tendency on many roads to a more extended installation of heavier models. On a few roads, which handle a considerable amount of drag freight, the 2-8-0 type in heavy models is still favored. The adoption of the Pennsylvania of the 2-10-0 type for heavy freight service is one of the most striking features in recent locomotive design. A number of trunk lines on which heavy grades are encountered on certain divisions, have placed during the past two years large orders for locomotives of the 2-10-2 type. While many of the roads using this type are in the West, the largest order to 1923 was that of the Baltimore & Ohio for 75 of the heaviest design yet built.

The Mallet type is not as generally favored as formerly. In 1922 there were orders for only 116 articulated locomotives and only four orders of any size. In 1923 the total number fell to 53, all but two of which were for only four roads. None of the roads ordering in 1923 were the same as those which ordered in 1922.

For passenger-train service the 4-6-2 continues to be far the most-used type. Many of those ordered exceeded 300,000 lb. in weight. A large number of orders for the 4-8-2 type have been placed during the past two years and the list of roads now using this type includes most of the larger systems and many smaller ones. The 4-8-2 type is not only employed where long and heavy passenger trains have to be hauled in territory where the grades are an important factor, but are finding an increasing field of usefulness particularly in the East, where a number of roads are using them for handling fast-freight traffic. The 4-6-0 type has again been brought into prominence by the Pennsylvania, this road having built 40 of an unusually heavy and modern design for branch lines and places where a much heavier 4-6-2 type was not required. Other important roads, while not ordering new locomotives of this type are remodeling older equipment and adding such features as superheaters, outside valve gear, and other devices not applied when the locomotives were built. One striking feature of the locomotive orders for the past two years is the practical disappearance of the 4-4-0 and the 4-4-2 types, which not so many years ago were common standards.

Attention is called to the reintroduction during the past year of the three-cylinder locomotive. This type is not a pioneer development, as it was tried out many years ago in England and also in this country but was gradually abandoned here. Two locomotives of this type are now in operation on American roads and the results appear to be quite promising. (*Railway Mechanical Engineer*, vol. 98, no. 2, Feb., 1924, pp. 76–79, *sg*)

Tests on New Electric Passenger and Freight Locomotives

Description of tests carried out at the Erie Works of the General Electric Company on two electric locomotives. These tests were in the nature of a public demonstration and were made on about $4^1/_4$ miles of track forming a portion of the Eastern Division of the East Erie Commercial Railroad.

The passenger locomotive was built for the Paris-Orleans Railroad in France and was guaranteed to operate successfully in

regular service at speeds up to 81 m.p.h., but during the test run a sustained speed of 105 m.p.h. was reached, and even at this speed the locomotive was said to have shown remarkably easy riding qualities.

The features of design which make it possible to run this locomotive at such high speeds are, (1) a gearless motor, and (2) a special construction of the leading and trailing trucks. The gearless-motor drive, which is of the bipolar type, removes the restrictions as to permissible armature speed which sometimes limit the safe speed of a locomotive. To do this in the motor described the armature and fields are allowed a vertical movement entirely independent of each other.

An important feature of the truck design is the type of centering device. The weight of the outer end of the cab is carried on two rollers which rest on inclined planes attached to the truck near the drawbar. Any lateral motion of the truck causes one or the other of these rollers to move up the corresponding inclined surface, thus lifting the weight of the cab and transferring this weight to the rail against which pressure is being exerted. As the roller returns to its normal position, the cab quickly comes to rest at the center point and the design thus avoids the tendency to oscillation, which in many types of locomotives limits the maximum speed attainable. Numerous tests have demonstrated that any tendency toward periodic oscillation is immediately damped out by the action of this device.

The freight locomotive (150-ton) tested at about the same time is of the geared type and was built for the Mexican Railway Co., Ltd. Its particular feature of interest is the high capacity per unit obtained by using three two-axle trucks under each cab. These locomotives have a total one-hour blown rating of 2736 hp. and a corresponding tractive effort of 54,000 lb. at 19 m.p.h. Owing to the distribution obtained by using six axles with two driving motors on each truck, the moderate weight of 50,000 lb. per axle is secured. Two of these units operating in multiple, as will be required in the freight service of the Mexican Railway, will give the equivalent of a 5040-hp. locomotive having a continuous tractive effort of 97,000 lb. at 19.5 m.p.h.

Interesting regenerative braking tests were made. For these tests a steam engine and the Mexican electric locomotive were coupled together and started from the west end of the track. The first run was made at 8.7 m.p.h., regenerating approximately 810 kw. The calculated drawbar pull on this trip was 57,640 lb. The first operating position on the electric locomotive was used placing all motors in series, while on the steam locomotive the booster engine was continuously in operation. On the second run the train was allowed to reach a speed of about 15 m.p.h. before regenerative breaking was applied. A speed of 15.5 m.p.h. was then maintained by regenerative-braking control, sending back approximately 1080 kw. to the substation. The drawbar pull calculated for this run was 43,440 lb. On the third run the speed held by the electric locomotive with the motors in parallel was 23.6 m.p.h. The amount of power regenerated was 1620 kw. and the calculated drawbar pull 40,450 lb.

In order to obtain a comparative test of the relative merits of geared drive as used on the electric locomotives and the coupled side-rod construction used for the steam locomotive, a tug-of-war contest was staged, using a Mikado steam locomotive. The total weight of this engine on the drivers, including the booster, at the time of the tests was 309,300 lb. as compared to a scale weight of 309,650 lb. for the Mexican locomotive. The two locomotives were therefore approximately on an equal basis as regards weight on the driving axles. The test was first started from a standstill, power being applied to both engines at a given signal. The electric locomotive had no difficulty in holding the steam locomotive and then pulling it backward. Other tests were made during which the steam locomotive was allowed to reach a low speed, and even with this advantage the electric had no difficulty in stopping and hauling the steam engine backward. Favorable comments were made on the effectiveness of the equalization of the electric-locomotive running gear which permitted the use of a tractive coefficient as high as 30 per cent when moving without slipping the wheels. In all of these tests the rails were well sanded before trial. From readings taken of the current used by the electric locomotive the drawbar pull exerted was calculated as follows:

Balanced drawbar pull at standstill	86,000 lb.
Electric locomotive hauling Mikado backward	94,000 lb.

In addition otheographic records were made of the steam locomotive operating at several speeds. (W. D. Bearce in *General Electric Review*, vol. 27, no. 2, Feb., 1924, pp. 98–103, 10 figs., *e*)

The Possibilities of a Diesel Locomotive

IN DISCUSSING the skeptical attitude of the majority of railroad men toward the question of the steam locomotive being displaced by one of the internal-combustion engine type, the writer of the editorial here abstracted claims that conservatism may be carried too far, and that, notwithstanding its obvious merits, the steam locomotive has certain very material defects.

Probably comparatively few railroad men realize the strides made during the last decade in the development of the internal-combustion engine of the heavy-oil type to which the name Diesel is usually attached. The thermal efficiency of such engines is high; they can be operated continuously for long periods of time; their stand-by losses are insignificant. As arguments against their widely extended adoption it must be recognized that they are frequently heavy, bulky, complicated, and of relatively high initial cost. They also possess certain characteristics which make their application to locomotive service far from an easy problem. Probably the most difficult of these problems is that of transmission, particularly in the larger units, and associated with this is that of starting under heavy load. Weight has often been a reason for not using Diesel engines in the past, but this objection has been largely overcome in the development of a high-speed engine for use in submarines. Without the Diesel, the submarine would not be the practical and effective device it is.

Engineers, both here and in Europe, are working hard on the problem of the Diesel locomotive. The limitations and requirements are better understood today than they ever were before, and this makes possible an intelligent handling of the issue. With suitable encouragement, the next few years should show rapid progress in the development of engines and transmissions for practical thermo locomotives for at least some American railroad traffic conditions. (Editorial in *Railway Mechanical Engineer*, vol. 98, no. 2, Feb. 1924, p. 70, *g*)

Railroad Buffer Springs

THE increasing weight of the rolling stock makes it necessary to employ shock-absorbing devices of correspondingly increased ability. From this point of view the circular spring developed by the Uerdingen Car Shops may be of interest.

As appears from Fig. 7, this spring consists of unsplit inner and

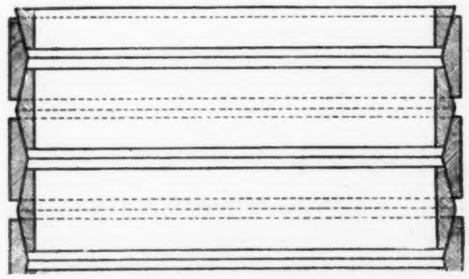

FIG. 7 BUFFER RING SPRING, ORIGINAL DESIGN

outer rings having wedge-shaped surfaces in contact with each other in such a manner that when subjected to an axial pressure the outer rings undergo an extension outward and the inner rings a compression inward. Because of this deformation the rings draw closer together, which means that the spring acts in the axial direction. It is essential, however, that during the motion of the rings with respect to each other there should be friction between their surfaces, as this produces an essential increase in the force of springing and at the same time effectively brakes the recoil of the springs. The article proceeds to give an extensive calculation of this type of spring which is not suitable for abstracting.

It is stated that springs have already been manufactured for the Central Railroad Administration in Germany with a carrying capacity of 50 tons, and even this may be considerably increased by the employment of certain auxiliary devices described in the original article. Fig. 8 shows how this type of spring may be ap-

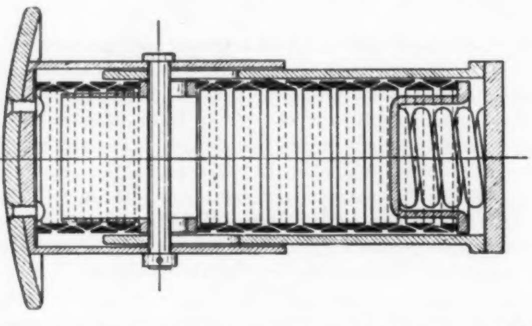

FIG. 8 RAILROAD BUFFER INCORPORATING THE RING SPRING SHOWN IN FIG. 7

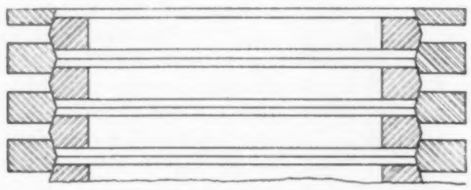

FIG. 9 A LATER MODIFICATION OF THE RING SPRING SHOWN IN FIG. 7

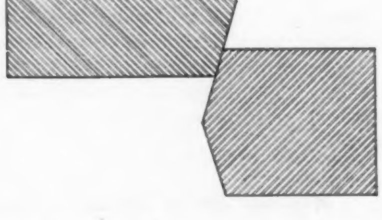

FIG. 10 FRICTION AREAS IN CONTACT IN THE RING SPRING SHOWN IN FIG. 9

plied in a railroad buffer. The main spring is in series with a small precompression spring used in order to facilitate the starting of a train. Figs. 9 and 10 show a modification of the spring shown in Fig. 7, together with a diagram of friction surfaces in contact with this modified spring. These two figures have not yet been published elsewhere and have been obtained through the courtesy of Oscar R. Wikander, a member of The American Society of Mechanical Engineers. (Ernst Kreissig in *Verkehrstechnische Woche*, Sept. 21, 1922, *o*)

SPECIAL MACHINERY

A Dynamic Balancing Machine

DESCRIPTION of a machine developed by the Peerless Pump Co. for use as a balancing machine. It is claimed that this machine registers in thousandths of an inch variation in actual running speeds from previous still balance of revolving units for turbine centrifugal well pumps.

The machine illustrated in the original article consists of a vertical spindle connected by universal joint to a 2-hp. motor which is mounted on an angle bracket. The only other bearing on the spindle in addition to this usual coupling is a radial ball bearing which supports the upper end of the shaft while gaining the desired speed. But this bearing is lowered by means of a hand lever as soon as the desired operating speed is obtained, giving the spindle about $^1/_8$ in. clearance to vibrate at will during the test. Deflections are registered by means of a Starrett Tool Co. deflector indicator, the middle of which rests against the spindle, mechanically registering the amount of vibration on a dial. (*Western Machinery World*, vol. 15, no. 2, Feb., 1924, p. 55, 2 figs., *d*)

TESTING AND MEASUREMENTS

A Constant-Pressure Bomb

THIS report describes a new optical method of unusual simplicity and good accuracy which is suitable to the study of the kinetics of explosive gaseous reactions. It deals with a part of an investigation of the rates of explosive gaseous reactions being carried out at the Bureau of Standards at the request and with the support of the National Advisory Committee for Aeronautics.

The device is the complement of the spherical bomb of constant volume, and extends the applicability of the relationship $pv = nRT$ for gaseous equilibrium conditions to the use of both of the factors p and v.

The method substitutes for the mechanical complications of a manometer placed at some distance from the seat of reaction the possibility of allowing the radiant effects of the reaction to record themselves directly upon a sensitive film.

It is possible the device may be of use in the study of the photoelectric effects of radiation.

The method makes possible a greater precision in the measurement of normal flame velocities than was previously possible.

An application of the method in the investigation of the relationship between flame velocity and the concentration of the reacting components, for the simple reaction $2CO + O_2 = 2CO_2$, shows that the equation $k = \frac{s}{C^2_{co}C_{o_2}}$ describes the reaction. Here s is the rate at which the flame advances in the stationary stage or the flame velocity relative to the reacting components, while C_{co} and C_{o_2} are their partial pressures. Furthermore, the velocity factor k is found to be remarkably constant for this reaction over the entire range of mixture ratios. Values of k as functions of the percentage of CO in O_2 + CO as well as values of the denominator in the above equation are given in a table in the original paper. The paper also gives mathematical expressions for the pressure drop between two sides of the flame surfaces as well as the pressure inside the flame surface while combustion is in progress.

An approximate analysis shows that the increase of pressure and density ahead of the flame is negligible until the velocity of the flame approaches that of sound. (F. W. Stevens, in *National Advisory Committee for Aeronutics*, Report No. 176, 1923, 8 pp., 2 figs., *d*)

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

Glycerine-Water Solutions as Quenching Media

In connection with the series of investigations recently made by the American Bureau of Standards on steels used in the manufacture of precision gages, an effort has been made to find a quenching medium intermediate between oil and water. Some little time ago, quenching curves were taken of specimens cooled in water solutions of glycerine. Such solutions fill the gap effectively, so far as the cooling rates at high temperatures are concerned. On the other hand, glycerine and its water solutions cool distinctly faster in the lower temperature ranges than quenching oil. This appears to be a desirable property. As a commercial quenching medium, glycerine or its water solutions should not be unduly expensive, for although the first cost is high, glycerine does not decompose to any great extent on heating, as is the case with oils. The composition of glycerine-water solutions may be easily maintained by hydrometer tests. The solutions do not give off irritating fumes, are harmless to the worker, and possess other desirable advantages. (*The Engineer*, vol. 137, no. 3554, Feb. 8, 1924, p. 147.)

Correspondence

CONTRIBUTIONS to the Correspondence Department of MECHANICAL ENGINEERING are solicited. Contributions particularly welcomed are discussions of papers published in this journal, brief articles of current interest to mechanical engineers, or comments from members of The American Society of Mechanical Engineers on activities or policies of the Society in Research and Standardization.

Forces Acting on Ball-Bearing and Roller-Bearing Connecting Rods

To the Editor:

A study of the forces acting on the friction surfaces of a ball-bearing or roller-bearing connecting rod shows clearly why balls or rollers used in this capacity are subject to excessive wear. Experiments conducted in this country and Europe on ball- and roller-bearing connecting rods have met with varying success, but there are few instances in which manufacturers standardize on this use of ball or roller bearings. The following analysis discusses the forces acting on the ball or roller during one revolution of the crankshaft.

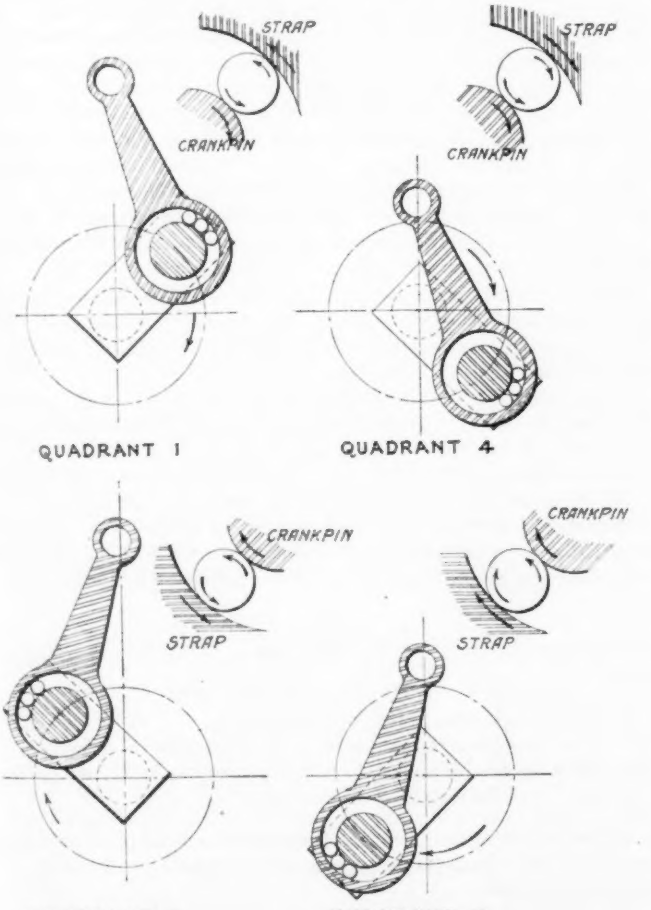

Fig. 1 Forces Acting on Ball-Bearing and Roller-Bearing Connecting Rods

Referring to Fig. 1, the sectional views show the crankshaft revolving clockwise or opposite to the numbering of the quadrants. As the crankshaft revolves the crankpin, being a fixed member, rotates, while the connecting-rod strap oscillates. In quadrant 1 this rotation of the pin and oscillation of the strap are in opposite directions and tend to impart a rolling motion to the ball as is shown in the enlarged sectional view. But the crankpin rotates at a greater rate of speed than the strap oscillates, with the result that the ball will slip rather than roll. It will wear out of round quickly and the excessive friction will cause heating. However, there is one case in which the ball will roll freely. If the ball race on the strap is exactly twice the diameter of the ball race on the pin the speed of the strap and the pin will be the same, and since their directions of motion are opposed, the ball will roll freely. This is not a very practical situation, though, because it involves using extra large balls or rollers.

The effect of slippage in this quadrant is magnified by the thrust of the connecting rod during the power stroke. The contact surfaces are pressed hard against the balls with the result that the friction caused by slippage will be intensified.

With the exception of the connecting-rod thrust the same forces act on the ball while the crankpin is in quadrant 2. As will be seen from Fig. 1, the direction of rotation of the pin is the same in all quadrants and the strap oscillates in the same direction in both quadrants 1 and 2.

In quadrants 3 and 4 the direction of oscillation of the strap is changed. The sectional views show how the strap tends to rotate the ball clockwise while the pin sets up a counterclockwise force. Free rolling is prevented and slippage will result. Excessive heat will be generated and the ball will soon wear out of round. In quadrant 4 the thrust of the connecting rod adds to the intensity of the friction.

There is no point in the complete cycle where the forces acting on the balls or rollers are normal. In one test with ball-bearing toggles on air drills the writer saw a set of balls that were worn almost square. It is probable that balls or rollers can be manufactured which will stand up, but the forces described above cannot be changed. The result is that the friction surfaces of the crankpin and the strap will quickly deteriorate and excessive heating will still take place.

N. K. Stitt.

Cleveland, Ohio.

Regarding the Engineering Societies Library Lending Service

To the Editor.

The lending plan adopted by the Engineering Societies Library Board will, in a measure, make the Library of Service to members who do not have the opportunity of visiting New York. It is a step in the right direction and one that I have advocated for several years.

The proposed rental fee seems unusual, but may be justified by circumstances. I believe that the primary purpose should be to enable members to determine by personal examination whether a book meets their needs. If it does they can purchase a copy or have photostats made of the important parts. Such an inspection should take only a short time, and in order to insure the prompt return of books to the Library I would suggest a sliding scale of charges instead of a flat rate. Also there should be no charge for, say, the first week, with an additional allowance for time of transit. At present the photostat service is of little use to many members because they cannot determine in advance the value of a reference; furthermore the cost is considerable, so that after a few disappointments one is chary about ordering blindly.

I hope, however, that this is only a beginning and that the service will soon be extended to include foreign-language books. Books of American publishers are usually available in most libraries and, if not, may be obtained from the Library of Congress with little difficulty and without a rental fee. Moreover, publishers are usually glad to send copies of their books for examination, so that their value may be determined in advance of purchase. Foreign books are not so accessible. I am quite sure that the larger percentage of the members of the four national societies do not live in the New York metropolitan district or find it convenient to go

to the Library; therefore, if the Library is to be of greatest service its books, no matter in what language, should be made available, under proper safeguards, to any member, no matter where he may live. I am aware that this raises the question of duplicate copies, but I am not yet convinced that the member who happens to be fortunate enough to personally go to the Library has any right to expect that a particular book shall be kept there for his possible call, resulting in the denial of a specific request for a book by some one not so situated. Personally, I should not feel that an injustice had been done if, on the few occasions I have the opportunity of visiting the Library, I should find that the book I wished to consult had been sent to a distant member, provided I knew that it would be returned to the Library promptly and that it would then be sent to me under the same conditions.

This question concerns many of us, and I should be glad to know what the Library Board's reasons are for the restrictions they have imposed.

F. G. Hechler.

State College, Pa.

To the Editor:

When I saw the announcement of the establishment of a lending service by the Engineering Societies Library, I was delighted. But my joy was short-lived, as I discovered upon reading the announcement that the service was applicable only to those technical books which are already accessible to nearly everybody.

Perhaps the Library Board has good reasons for confining the service to the books which it specifies in its announcement, but what they are I am unable to divine. Certainly it would seem that the only equitable arrangement would be to extend the service to all the books, periodicals, and transactions of societies, except frequently used books of reference and current periodicals.

Such a solution of the problem would be a great boon to those members of the associated societies who, like myself, get to New York about once every ten years, or less frequently. On the other hand, the plan adopted will be of insignificant advantage to members engaged in serious research outside of New York City.

In my judgment, to make completely available to all the members of the associated societies the great technical resources of the Engineering Societies Library would be a tremendous incentive to engineering research throughout the country. I ardently hope, therefore, that it will be done.

W. H. Rasche.

Blacksburg, Va.

To the Editor:

The new lending service on the Engineering Societies' Library should prove a valuable asset to all members of the constituent societies, but its real worth will be to those in remote districts. There are probably no professional men whose problems are of so general a nature and who require such specialized technical data. The maintaining of private libraries complete enough to serve all purposes is impossible; new editions of old books are constantly appearing, new books on specialized subjects are being rapidly published. Their only recourse, therefore, is to some library service which can systematically keep pace with these rapid changes.

The college and university libraries have been helpful to those members who are affiliated with, or near them. Unfortunately, however, too few engineers have ready access to these sources. In many cases, too, the number of technical books in such libraries is not large, and more and more difficulty is being experienced in keeping the collections up to date.

With the facilities and means at their disposal the engineering societies should be able to maintain as complete a technical library as can be found. With the privilege of access to this information and with the further privilege of buying, at publishers' prices, the books which seem upon inspection to be particularly fitted to their needs, engineers should find this lending service of great help, and they should endeavor to make it a permanent part of the Library's plan.

J. P. Calderwood.

Manhattan, Kan.

A.S.M.E. Boiler Code Committee Work

The Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information as to the application of the Code is requested to communicate with the Secretary of the Committee, Mr. C. W. Obert, 29 West 39th St., New York, N. Y.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council of the Society, for approval, after which it is issued to the inquirer and simultaneously published in Mechanical Engineering.

Below are given the interpretation of the Committee in Case No. 411 (reopened), as formulated at the meeting of January 10, 1924, and approved by the Council. In accordance with the established practice of the Committee, the names of inquirers have been omitted.

Case No. 411 (Reopened)

Inquiry: Par. 212*c*, which permitted increasing the pitch of staybolts on cylindrical surfaces over that required for flat plates, had, about two years ago, been held in abeyance pending the revision of the Boiler Code, but nothing has been left in its place. In view of this, what rules should be followed pending the publication of the revised Code?

Reply: It has been proposed to revise Par. 212*c* as follows, dividing it into items *c* and *d*, and the Committee recommends to the state inspectors that these rules be followed in place of the rules now given in Par. 212*c* of the Code:

c A furnace for a vertical fire-tube boiler, 38 in. or less in outside diameter, which requires staying, shall have the furnace sheet supported by one row of staybolts, or more, the circumferential pitch not to exceed 1.05 times that given by the formula in Par. 199.

The longitudinal pitch between the staybolts, or between the nearest row of staybolts and the row of rivets at the joints between the furnace sheet and the tube sheet or the furnace sheet and mud ring, shall not exceed that given by the following formula:

$$L = \frac{(220 \times T^2)^2}{(P \times R)}$$

where

L = longitudinal pitch of staybolts, in.
T = thickness of furnace sheet in sixteenths of an inch
P = maximum allowable working pressure in lb. per sq. in.
R = outside radius of furnace, in.

except when this value is less than the circumferential pitch, in which case the longitudinal pitch may be as great as the allowable circumferential pitch.

The stress per square inch in the staybolts shall not exceed 7500 lb. and shall be determined in the way specified in section *d*.

d In furnaces over 38 in. in outside diameter and combustion chambers not covered by special rules in this Code, which have curved sheets subject to external pressure, that is, pressure on the convex side, both the circumferential and longitudinal pitches of the staybolts shall not exceed 1.05 times that given by the formula in Par. 199.

The stress per square inch in staybolts shall not exceed 7500 lb., based on a total stress obtained by multiplying the product of the circumferential and longitudinal pitches by the maximum allowable working pressure.

Addenda to Code

The Boiler Code Committee has for several years had under consideration the formulation of rules to cover the strength of shells or drums pierced with any number of holes placed along

a longitudinal line without reinforcement. As a result of its studies the following rules are presented. Criticism and comment thereon from anyone interested in this subject are invited. Discussions should be mailed to C. W. Obert, Secretary of the Boiler Code Committee, 29 West 39th Street, New York, N. Y., in order that they may be presented to the Boiler Code Committee for consideration. It is the purpose of the Committee to present the rules finally agreed on to the Council of the Society for approval as an addition to the Boiler Code. A set of curves for determining the strength of the diagonal ligaments similar to that given on the folder between pages 48 and 49 of the 1918 edition of the Code, but extending over a larger field, will be published with the rules.

Rules for Determining Efficiency of Drum Sheet for Any Series of Holes That May Be Placed Longitudinally Without Reinforcement

1 Where the tubes are arranged in groups along lines parallel to the axis and the same spacing is used for each group, and the length of each group does not exceed the outer diameter of the drum, the efficiency of the ligaments for one of the groups as computed by the rules shall not be less than the efficiency on which the maximum allowable working pressure is based. Where the groups of tubes are longer than the outer diameter of the drum, or where the tubes are unsymmetrically spaced, the average ligament efficiency for a length equal to the outer diameter of the drum for the position that gives the minimum efficiency shall not be less than the efficiency on which the maximum allowable working pressure is based.

2 The ligament efficiency computed between the centers of any two adjacent holes shall not be less than one-half the efficiency on which the maximum allowable working pressure is based.

3 Any holes shall be limited in diameter to such with which it would be possible to form recesses completely around the hole from both sides of the sheet and with a plane surface at the bottom of each recess provide thereby a tube seat $^3/_8$ in. in width between the two planes which are perpendicular to the axis of the hole and which form the bottoms of the recesses.

4 For holes placed longitudinally along a drum but which do not come in a straight line the above rules shall hold, except that in the case of the diagonal ligaments the equivalent width of a ligament for equal strength if the holes were in the same straight longitudinal line shall be used. To obtain the equivalent width the longitudinal pitch of the two holes having a diagonal ligament shall be multiplied by the efficiency of the diagonal ligament.

High Pressure, Reheating and Regenerating for Steam Power Plants

(Continued from page 183)

creased to values less than 100 per cent the high pressures are still less attractive. With coal costing $8 per ton the best pressure for base-load conditions would appear to be near 1000 lb. per sq. in.

Operating Characteristics

Experience with high-pressure equipment and with auxiliary apparatus which the use of high-pressure steam appears to involve is as yet exceedingly limited. No one is today really in position to say positively that the high-pressure equipment now coming into use will operate with that smoothness and certainty required to justify its use for the sake of the increased thermal efficiency obtainable. Under such conditions it would seem to be best to use first the simplest types and to progress toward the more complicated if further experience indicates such progress to be desirable. From such a point of view the simple Rankine cycle would be best if it gave sufficient promise of increased efficiency with increased pressure. Unfortunately it does not, and it is therefore necessary to consider a more complicated cycle of operation. Our present knowledge indicates two choices, that involving regenerative heating only and that involving reheating with or without regeneration. Of the two, the regenerative cycle is unquestionably the simpler, and in fact it is hardly more complicated than the Rankine now in use.

Some Probable Developments

Considering all of the factors which enter into the problem, it seems to the authors that the high-pressure regenerative plant is the most promising for commercial development. It is certainly true that the performance here estimated for such a plant can be further improved by using a turbine designed to separate and remove water formed during expansion. Some of the designs now available provide for such drainage at the bleeder points to a certain extent, but it seems probable that the best results cannot be attained unless effective moisture separators are actually built into the turbine structure.

It is essential to note that economizers become of less value with the regenerative cycle as the initial steam pressure is increased. This naturally follows from the increasing temperature of feedwater leaving the regenerative heaters. The high turbine-room efficiency is therefore obtained to a certain extent at the expense of boiler-room possibilities. This suggests immediately that air heaters be used with such plants in order to conserve waste heat not available for use in economizers fed with high-temperature water.

It is obvious that it will be necessary to heat the air in such devices to temperatures from 100 to 200 deg. fahr. above normal air temperature if full conservation of the waste heat is to be made.

General Conclusions

The studies outlined in this paper, together with others with which the authors are familiar, indicate plainly that the improvement in economic results to be expected from the use of higher steam pressures in plants designed to take full advantage of the possibilities latent in the use of such pressures are sufficiently great to make it appear quite probable that the more progressive engineers and executives will construct plants of this character in ever-increasing numbers.

It must be recognized that high-pressure equipment necessarily carries high development charges at the present time, and that this fact, coupled with uncertainty with respect to the performance of equipment of untried types, must to a certain extent retard its adoption. It is therefore to be expected that higher pressures will be adopted first and more frequently in connection with plants of the base-load type and in regions in which fuel costs are high.

The authors feel that steam pressures of the order discussed in this paper should no longer be regarded as of theoretical interest only. Most of the major problems involved in the design and arrangement of equipment for utilizing such pressures have been solved or are nearing what appear to be satisfactory solutions, and it is believed that careful engineers who are thoroughly familiar with the peculiar features involved in this sort of work can safely install equipment for even the highest pressures here considered when the circumstances and conditions of use justify such installations.

Certain of the factors in this paper have been calculated for maximum temperatures of both 700 and 800 deg. fahr. The authors feel that calculations for 800 deg. fahr. are at the present time of minor interest, as they do not believe that materials and designs now available may be considered adequately safe for use with such temperatures. It is exceedingly difficult to state categorically any definite upper limit of temperature, but it is nevertheless felt that a figure lying between 700 and 750 deg. fahr. represents the safest upper limit steam temperature at the present time.

The authors believe that this study indicates even with the present type of turbine the regenerative cycle is the best one to use in large stations, as it ranks very high from the standpoint of fuel consumption, operating characteristics, and first cost throughout the entire range of pressures, but particularly so above 600 lb. per sq. in. With a turbine which the authors believe can be developed so as to remove the moisture to a considerable degree, this cycle will give still better economy, and it seems altogether reasonable to expect that this equipment in the turbine room, combined with that now developed to yield high boiler-room efficiency, will give station economy that will pay handsomely for the increased investment.

MECHANICAL ENGINEERING

A Monthly Journal Containing a Review of Progress and attainments in Mechanical Engineering and Related Fields, The Engineering Index (of current engineering literature), together with a Summary of the Activities, Papers and Proceedings of

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The Need for Federal Air Law

Edward P. Warner

When the armistice was signed five years ago civil flying in the United States was under the control of the Federal Government, and privately owned aircraft could not be operated without license from Washington. Instead of retaining that control, however, as similar control was retained by the government of nearly every other nation in the world, our national government relinquished it, and left it to states, counties, and municipalities to pass aircraft laws without restraint or guidance. Already the result has been the enactment of a perfect flood of statutes, ranging from the carefully planned, accurately phrased, and stringently enforced laws of a few states down to certain ordinances the provisions of which can only be described as comic, but which are none the less capable of having a paralyzing effect on the operation of aircraft for commerce or pleasure within the territory where they are effective.

The folly of leaving the regulation of aircraft in the hands of the individual commonwealth should have been apparent to any American who has ever driven an automobile across state lines, or even from city to city within a single state, and who has suddenly found himself obliged to conform in letter and in spirit to new laws, regulations, and practices whereof he had known nothing. The obvious need that now exists for the standardization of traffic rules in the cities furnishes a sufficiently powerful object lesson on the complexity of the problem with which the aircraft pilot of the future may find himself confronted. Flying at quite moderate speed an airplane can travel from Portland, Maine, to Washington in six hours without a stop, and it will cross nine states and the District of Columbia in doing so. If ten distinct sets of laws must be learned and complied with before starting such a flight, aerial navigation in America will be placed under a stifling handicap.

It is not only because of the menace of a conflict of laws, however, that federal regulation is desirable. If there were no state laws on the subject at all, Congressional action would be even more necessary than it is now, for if the airplane and the airship are to gain recognition as safe and sane instruments of transportation, operating without sensationalism and with the sole object of rendering the greatest possible economic service to the community, it is essential that the pernicious activities of incompetent pilots flying unsafe machines should be relentlessly suppressed. The interests of the potential passengers in aircraft demand that the reckless and unskilled be eliminated from the field. The interests of the innocent bystanders on the ground below make the same demand. Last, but of no less importance, the interests of those operators of airplanes who seek to combine a maximum of safety with a maximum of service point in the same direction, for every accident to an unfit or improperly operated airplane is an additional obstacle placed in the way of those whose machines are kept in perfect order and whose pilots are the best that can be found. Capital will never be attracted to the operation of aircraft while there exists the likelihood of competition from the half-trained pilot who buys an obsolescent airplane for two or three hundred dollars and operates it without repairs until it literally falls to pieces. Commercial flying can only be put on a stable footing when some central authority has at least a right of supervision over what is done and over the manner of its doing.

In addition to providing protection for the users of aircraft in commerce, a Bureau of Aeronautics will serve as a medium for the compilation and the exchange of information. In every European country there exist accurate and complete official statistics on the amount of flying done, its nature, and the number and gravity of the accidents that occur. The preparation and publication of such data serve alike to stimulate public confidence and to furnish a basis for planning the operations of new companies and for the establishment of insurance rates. Aircraft insurance can be little more than a gamble until statistics of unquestionable authenticity on the extent of the hazard are prepared, and until such statistics are available the prominence given by the press to sensational aircraft mishaps will always lead to gross overestimation of the risk of air travel on the part of the general public.

The creation of a Bureau of Aeronautics would be highly desirable even if all flights were to begin and end within our own boundaries. When operation becomes international, however, the creation of a central control becomes absolutely vital. Under the International Air Navigation Convention, ratification of which has so far been withheld by this country alone among the principal allied and associated powers, states undertake to recognize each others' certificates of registration and license. They also undertake, however, to conform to certain general principles in passing on the qualifications of pilots and on the safety of aircraft, and so long as we have no authority competent to act in accord with those general principles we shall be aerial outlaws, and aircraft belonging to American citizens will be able to enter Canada and other foreign territory only by virtue of international courtesy separately extended in each particular case, or as a sequel of the signing of a separate treaty with each country with which we may expect to have aerial traffic.

A Bureau of Aeronautics should have been functioning during the past five years. The need for such an organization has grown constantly more apparent, and we have penalized ourselves heavily by failure to create it, but it is not yet too late. Those who appreciate the great potentialities of aircraft for commercial transport and wish to see them realized should give very careful consideration to such measures as the Civil Aeronautics bills recently introduced in the House of Representatives by Congressman Winslow and in the Senate by Senator Wadsworth.

Edward P. Warner.[1]

The development of aeronautic photographic mapping is shown by the fact that Greater New York and surrounding territory, comprising approximately 625 square miles, will be completely mapped early in April. To accomplish this, 3000 miles were flown and 2000 exposures made. Two maps are being prepared, one including approximately 400 square miles within the city limits and employing a scale of one inch to 600 feet, and the other, covering 625 square miles, a scale of one inch to 2000 feet.

[1] Assoc. Prof. of Aeronautical Engineering, Massachusetts Institute of Technology, Cambridge, Mass. Jun. Mem. A.S.M.E.

The Registration Laws

WHEN the results of a recent canvass of engineers are considered it is apparent that there is no unanimity of opinion as to the advisability of laws relating to the licensing or registration of engineers. There is a decided lack of interest on the part of engineers affected by the law in the provisions of that law. During recent years the question of registration has been growing in importance. At the present writing it is known that twenty-three states have enacted registration laws, and similar legislation is pending in a number of other states. In at least seven states legislation proposing registration laws has been defeated partly through the efforts of engineers who were opposed to some of the provisions of these measures. It appears, therefore, that in general there has gradually developed a spirit of resignation to what would seem to be the inevitable and a disposition to endeavor to influence this legislation so as to secure the most equitable and worth-while regulations possible.

The mechanical engineers in Pennsylvania sent questionnaires to as many engineers as possible in that state in an effort to establish definitely whether the law now in existence is fundamentally good, and if not, what measures, if any, should supplant or amend it. The consensus of opinion previously seemed to indicate that the law and the administration thereof were unsatisfactory. When it was repealed by the state legislature during the last session, the governor vetoed the repeal so that the law is still in force, despite the fact that one of the state courts has decided that it is unconstitutional. The concisely worded questionnaire which went to the members of over fifty engineering organizations brought almost no returns of value, so that the engineers of the state are not prepared to make recommendations that would be representative of the opinions of the majority of engineers.

The laws providing for the registration of engineers, surveyors, and architects in many other states, notably New York, were enacted so recently that the opinion of engineers in these states has apparently not crystallized as to the value of the law. In states where the law demands registration of state engineering employees and employees of large engineering corporations, considerable fault has been found with the provisions of the law and it is the almost unanimous opinion in these states that certain modifications are desirable, while many engineers are to be found in other states who are of the opinion that any law of this sort is a hindrance to the profession and of no use in protecting the public. All seem agreed, however, that there should be a codification of the engineering registration laws of the several states so as to secure uniformity which will permit engineers to practice under the same conditions in all states and so that all states will have the same conditions as to reciprocity.

Perhaps the greatest factor working in this direction is the Council of State Boards of Engineering Examiners. This body is composed of representatives from most of the states that have registration laws, and meets once a year for the purpose of reviewing and standardizing the work of the boards and securing the fullest coöperation between those states where a registration law has been enacted. The several state boards recognized the necessity of securing articles of agreement on reciprocity and the following states are now working under this agreement: Arizona, Colorada, Florida, Indiana, Iowa, Louisiana, Michigan, Minnesota, North Carolina, Oregon, South Carolina, and West Virginia.

At the last meeting of the Council of State Boards it was voted that registration should be compulsory, that the certificate of registration should not necessarily show the branch of engineering, that all examinations should be both written and oral, that the fee for engineers should be \$25 with an annual renewal fee of \$5, and that no fee should be charged for the issuance of reciprocity. The officers of this board, as it is now composed, are G. M. Butler, of Arizona, President; George E. Taylor, of West Virginia, Vice-President; T. Keith Legare, of South Carolina, Secretary-Treasurer.

The salient features of most of the laws thus far enacted are substantially as follows:

1 To register the practice of engineering, architecture, and land surveying and to make such registration applicable to all classes of the same. In a few instances structural engineers are specifically named, but such instances are rare. In general, every engineer, architect, or land surveyor is required by the law to obtain a license.

2 Most of the laws provide that one must register six months after the law becomes effective. In some instances twelve months is allowed.

3 In all instances a penalty is specified for non-conformity. The general run of the penalties fixed is not less than \$100 nor more than \$500 or from three to six months imprisonment, or both fine and imprisonment.

4 The professional requirements generally specified are six years of actual practice with an allowance of two years of the six for a college course in engineering. The law grants credit of a year for each year of teaching or of study in a school of engineering of a standing satisfactory to the Board.

5 It is usually left to the registration boards whether one shall take an examination. In the main the practice has been to grant licenses upon the showing of documentary evidence of qualification supported by letters of endorsement.

6 The fees run from \$15 to \$25, with an annual renewal charge of from \$1 to \$10. In the majority of states the renewal fee is \$5. Some states require an application fee.

7 Renewal of license is required annually in all but some six states. In one of these the period is five years, in others the period is either not specified or the license is good until revoked.

8 In most instances non-resident engineers are permitted to practice thirty days per year without taking out a license. Some states allow as much as ninety days per year. The requirements for non-resident applicants are usually the same as for resident engineers. An engineer legally qualified in his own state to practice professional engineering may practice 30 days in Minnesota without registering.

A careful study of the laws indicates that in the main there is a striking similarity.

American Engineering Council, as well as its predecessor Engineering Council, has always taken the stand that it could not definitely defend or condemn registration legislation because of some differences of opinion held by constituent members. Its interest in the past has therefore been centered principally in trying to secure uniformity in the registration laws throughout the states so that they would not be detrimental to the public interest which the Council has sought to defend, and so that they would cause the minimum amount of trouble to the engineers concerned.

A. C. Oliphant.[1]

Industrial Mobilization for the Production of War Material

MECHANICAL engineers who have struggled with the production of war materials under conditions which left an indelible impress on the mind, cannot but be greatly pleased with the progress made by the War Department in perfecting plans for industrial mobilization. The Assistant Secretary of War, who is charged by the National Defense Act of 1920 with the assurance of adequate plans and organization to provide material in time of national emergency, has announced that the list of items for war material has been completed. He has asked for the coöperation of industry in putting into effect plans for rapid production.

The most important problem in rapid production is the provision of adequate gages and tools. It is readily apparent that peacetime work in producing these requisites is absolutely necessary. This in turn involves a settled design if the tremendous expenditure for tools is not to be wasted. Further, the manufacturers of war material must have concise and definite information about the requirements of the material and methods of manufacture.

In this connection, a recent editorial in *Engineering* (London) reviews the experience of the British in getting production on war material and makes definite suggestions as follows:

> Should another war of any magnitude unfortunately occur, the strain on our mechanical resources is likely to be even greater than during the last, and with competent engineering direction the Army Council would certainly see the necessity of being prepared with such things as jigs and gages for distribution among civilian firms. Another lesson which ought

[1] Ass't Secretary, Amer. Engr. Council, Washington, D. C. Mem. A.S.M.E.

to have been learnt is the need for adequate instruction to manufacturers who are asked to take up the specialized and unfamiliar work of producing munitions. A small handbook should be prepared giving in the greatest detail the approved methods of manufacture of articles which will be wanted in quantity. Such a book would give dimensioned sketches of all special chucks, jigs, tools and gages, together with cutting speeds and feeds for the whole series of the operations required to produce the finished article. It would be issued to firms with whom contracts were placed, not as a statement of methods to be compulsorily followed, but as a description of apparatus and processes which could be relied on to produce the specified results. Thus equipped, a works manager could get his shops into full production with the least possible delay and without the dreadful waste of time and material otherwise involved in experiment to find out the best processes of manufacture. The knowledge of these matters which is so widely diffused now will be forgotten before the next war, and the same difficulty in getting a start on munitions will again be experienced unless steps are taken to prevent it.

Definitions of Terms Relating to Heat-Treatment Operations

FOR some time the American Society for Steel Treating has had under consideration the setting up of definitions of terms relating to heat-treatment operations, and has now made public the report of its Sub-Committee on Heat-Treatment Definitions as tentatively approved by its Committee on Recommended Practice. These definitions, which appear below, have been prepared by a committee consisting of R. M. Bird, Chairman; Prof. Bradley Stoughton, of Lehigh University; H. J. French, of the Bureau of Standards; Sam Tour, of the Doehler Die Casting Co.; and B. F. Shepherd, of the Ingersoll-Rand Co., and are submitted to the members of the engineering profession and other interested individuals for their consideration. Comments thereon are solicited and should be addressed to J. Edward Donnellan, Secretary to the Recommended Practices Committee, 4600 Prospect Ave., Cleveland, Ohio.

DEFINITIONS OF TERMS RELATING TO HEAT-TREATMENT OPERATIONS TENTATIVELY APPROVED BY THE RECOMMENDED PRACTICE COMMITTEE OF THE AMERICAN SOCIETY FOR STEEL TREATING, JANUARY 31, 1924

Foreword

During recent years heat treatments have become more and more complicated and as a result there has arisen certain confusion in regard to the meaning of commonly used terms. For instance, in one locality or trade any operation of heating and cooling resulting in a softening of the material is being called annealing, whereas in other places to "anneal" means not primarily "to soften" but to heat to above the "critical temperature" and to cool very slowly. Similar confusion as to the meaning and application exists in regard to other terms and as a result "annealing," "tempering," "normalizing," etc. are being used by different people to mean widely different things.

In any attempt to accurately define the terms commonly used in connection with heat treatment, the first question to decide and the most important one is: Do the terms relate to the heat treatment operation itself or to the results obtained by the treatment? In other words, is the term indicative of the structure or the conditions obtained or of the operation performed?

After careful consideration it appears most logical and most in keeping with present-day usage to have the terms so defined that they shall mean definite operations and shall not be considered as referring to the structures or general conditions resulting, although, in a great majority of cases, the structures or conditions resulting may be quite similar.

At first glance it would appear entirely unnecessary to coin any new words. It seems, however, that one of the reasons for the confusion that has come to exist is the lack of adequate terms with which to express the different operations and conditions met with. In suggesting the use of the term "loneal," an attempt is made to relieve the term "anneal" of some of the misuse which it suffers and to eliminate the term "draw" which has such wide application in regard to the mechanical operations performed on metals as distinct from thermal treatments.

In commercial practice the terms here defined will vary slightly, depending upon the material under consideration. A "relatively slow rate of cooling" does not mean the same thing for an alloy steel as for a plain carbon steel, but the general meaning of the terms should remain the same regardless of the material being treated. This must necessarily be the case if the term relates to the actual operation and not to the structure or the condition resulting from the operation.

Heatings and coolings during any part of which steel is worked mechanically, are excluded from the meanings of the terms here given.

By "heating" as appearing below is meant a thorough and uniform penetration of the heat.

By "critical temperature" as appearing below is meant that temperature which is customarily associated with the following phenomena:

a Hardening when quenched
b Loss of magnetism
c Absorption of heat
d Formation of solid solution
e Pronounced refinement of coarse grain upon cooling.

Heat-Treatment Definitions

Annealing. Heating above the "critical temperature," followed by a relatively slow rate of cooling.

Loneal. Heating below the "critical temperature," followed by any rate of cooling.

Normalizing. Heating above the "critical temperature," followed by an intermediate rate of cooling.

[NOTE—In good practice the heating is considerably above the "critical temperature."]

Spheroidizing. A long-time heating at or about the "critical temperature," followed by slow cooling throughout the upper part of the cooling range.

[NOTE—For the purpose of spheroidizing the cementite in high-carbon steels.]

Hardening. Heating above the "critical temperature," followed by a relatively rapid rate of cooling.

Tempering. Reheating, after hardening, to some temperature below the "critical temperature," followed by any rate of cooling.

Carburizing. Adding carbon, with or without other hardening elements, such as nitrogen, to wrought iron or steel by heating the metal below its melting point in contact with carbonaceous material.

Case-Hardening. Carburizing the surface portion of an object and subsequently hardening by suitable heat treatment.

Cyaniding. A specific application of carburizing where the object, or a portion of it, is heated and brought into contact with cyanide salt.

Investigation of the Effect of Phosphorus and Sulphur in Steel

THE Joint Committee on Investigation of the Effect of Phosphorus and Sulphur in Steel has recently issued a further progress report. This committee was organized in 1920 and includes authorized representatives from the following bodies:

United States Bureau of Standards
American Society for Testing Materials
American Railway Association, Mechanical Division
United States War Department
United States Navy Department
Society of Automotive Engineers
Society of Naval Architects and Marine Engineers
National Research Council, Engineering Division
Association of American Steel Manufacturers
Steel Founders Society of America
American Foundrymen's Association.

Preliminary committee reports are issued as official publications of the American Society for Testing Materials. Final publication will be made by the United States Bureau of Standards as a technologic paper.

The work of the committee is proceeding along the following lines: Two methods of introducing sulphur into the steel are recognized. Residual sulphur is that which is present in the steel from fuel, pig, or scrap. The committee has designated this as Series A material. Added sulphur is termed Series B material, and in this case the sulphur is added to the steel during the later stages of manufacture.

The sulphur content in the steels tested will vary from 0.03 per cent to 0.08 per cent, while other elements will be normal and as nearly constant as possible. Phosphorus content will vary between approximately the same limits.

The committee has determined to study six groups of steel in each series:

1 Rivet steel, tubes, etc.
2 Plate and structural shapes
3 Forgings
4 Wheel, tire, and rail steels
5 Spring steels
6 Castings.

Chemical and physical tests are, in general, being duplicated in laboratories at Watertown Arsenal and at the United States Naval Experiment Station. In each case a third set of samples is being retained at the United States Bureau of Standards, and a fourth set is usually retained at the works of the steel company manufacturing the sample steel. Steels are being tested in three conditions:

1 As rolled
2 Normalized
3 Quenched and drawn.

Determinations are being made of tension, torsion, shear, impact shear, and hardness values, both in longitudinal and in transverse specimens.

Test programs for Series A, Group 1, and for Series B, Groups 2, 3 and 4, are practically complete. Tests on Series A, Groups 2 and 3, are under way. Preliminary reports in pamphlet form have been issued on Series A, Group 1, and on Series B, Groups 2, 3 and 4.

That the committee is equipped both as to personnel and available laboratory facilities to carry on this important investigation, is evident from its membership. The investigation will be exhaustive and the findings conclusive. It is to be hoped that, in addition to the presentation of data, the committee will, upon completion of its work, include in its report formal conclusions drawn from its intimate knowledge of the data.

These might be used as the basis for later specifications for materials both wrought and cast, but a further hope is ventured that the door will not be locked so tightly as to make it impossible to take advantage of new processes or combinations of elements by which all physical requirements may be fulfilled. There is grave doubt in the minds of some engineers as to the propriety of limiting the use of materials by setting up rigid specifications as to chemical contents when all the necessary physical characteristics are met by steels which a few years ago would have been condemned solely because of their chemical composition.

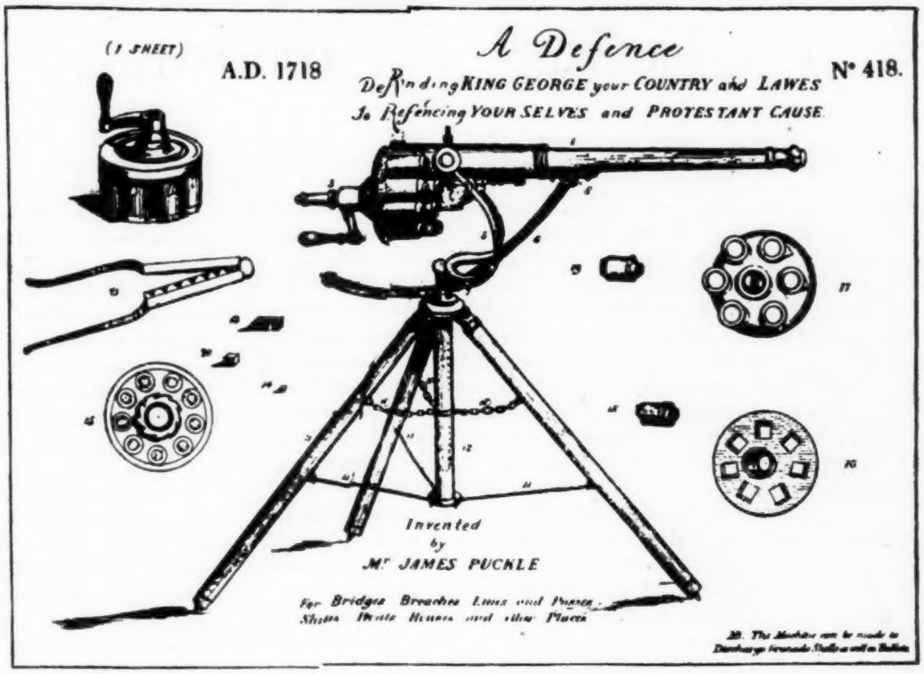
This investigation may therefore have vast economic significance. Deposits of fuel and ore not now available for development may prove to be, because of their location, of inestimable value. If it should develop that our metallurgical precepts are in error, even to a slight degree, as regards the harmful effect of these two elements, new fields of steel production at once become available for development.

J. C. Bannister.

The British Chartered Engineer

In THE United States licensing of members of the engineering profession has been regarded by many as a step toward the public recognition of engineers and the contribution they make to the advance of civilization. In this connection it is interesting to note the manner in which this problem has been approached by the Institution of Civil Engineers of Great Britain.

In a recent communication to the members of the Institution, its Secretary pointed out that the charter of that body presents the qualifications of those equipped with the particular knowledge required by the civil engineer. The Council accordingly turned their attention to the best means of obtaining authoritative recognition of the fact that corporate members of the Institution are chartered civil engineers, and of definitely confining to its members alone the right to use that designation. This object was attained by a supplementary charter of February 24, 1922, and by laws provided by His Majesty's Privy Counselor. The Council of the Institution urges upon every member and associate member of that body the desirability of his using the professional description "Chartered Civil Engineer" where the term "Civil Engineer" is now employed. The Secretary of the Institution further emphasizes the fact that the professional description now authorized, which connotes different qualifications of a high order, should not be subject in the public mind to the uncertainty of status which has tended to attach itself to a mere designation of membership in a society or to the confusion which results from unregulated employment of the term "Civil Engineer."



A Precursor of the Modern Revolver

In 1718 a British patent was granted to James Puckle for what resembles a modern revolver, a reproduction of which we are enabled to present above through the kindness of Wilfred Lewis, Mem. A.S.M.E., who has a photograph of the original patent. Students of firearms will be interested in the mechanisms shown and also in the manner in which the design of this firearm displayed the old superstition that square bullets would be required to kill Turks while round ones would be sufficient for Christians. The following explanation of the functions of the various parts of the gun forms a part of the original patent, but the difficulty of reproducing them suitably made it necessary that they be set in type.

1—The Barrel of the Gun
2—The Sett of Chambers Charged put on Ready for Firing
3—The Screw upon which every Sett of Chambers Play Off and On
4—A Sett of Chambers Ready Charged to be Slipped on when the First Sett are Pulled Off to be Recharged
5—The Crane to Rise, Fall and Turn the Gun Around
6—The Garb to Level and Fire the Guns
7—The Screw to Rise and Fall it
8—The Screw to Take Out the Crane when the Gun with the Tripod is to be Folded Up
9—The Tripod whereon it Plays
10—The Chain to Prevent the Tripods extending too far out.
11—The Hooks to Fix the Tripod and Unhook When the same is Folded Up in Order to be Carried with the Gun upon a Man's Shoulder
12—The Tube Wherein the Pivot of the Crane Turns
13—A Charge of 20 Square Bullets
14—A Single Bullet
15—The Front of the Chambers of a Gun for a Boat
16—The Plate of the Chambers of the Gun for a Ship Showing Square Bullets against Turks
17—For Round Bullets against Christians
18—A Single Square Chamber
19—A Single Round Chamber
20—A Single Bullet for a Boat
21—The Mold for Casting Single Bullets.

Mechanical Engineering at West Point

A SHORT COURSE in mechanical engineering was introduced early in 1923 at West Point in the department of civil and military engineering. The principles of steam and gas engines, transmission of power, principles of power plants, and the economy of fuels with special reference to conditions arising in the United States Army Supply Department, are the subjects that will be taught in this course. These changes were made in accord with a change approved by the War Department, eliminating the department of practical military engineering and distributing its courses to the departments of tactics and of civil and military engineering.

Engineering and Industrial Standardization

Standardization of Bolts and Nuts

THIS project was considerably stimulated as the result of a conference called by the Department of Commerce, Division of Simplified Practice, and held in Washington on February 19 and 20. This conference, which was called at the request of the National Association of Farm Equipment Manufacturers, was attended by approximately 50 delegates representing manufacturers, distributers, consumers and general interests. The delegates of the N.A.F.E.M. represented both of the first two groups, while the members of the Sectional Committee on the Standardization of Bolt, Nut, and Rivet Proportions who were present represented its twenty coöperating organizations which cover completely all four groups.

As is generally well known, this Sectional Committee on Bolt, Nut, and Rivet Proportions was organized and is functioning under the procedure of the American Engineering Standards Committee and is sponsored by the S.A.E. and the A.S.M.E.

Before the conference had progressed very far it became evident that the work before it was not limited to merely the elimination of variety and sizes but involved the more difficult question of technical standardization. It can now be reported, however, that the number of plow bolts was reduced from an unknown number to four, known as Nos. 3, 4, 6, and 7. Bolts Nos. 3, 6, and 7 have round heads and No. 4 has a square head. They have angles under the head of 80, 80, 40, and 60 deg., respectively, and their nominal diameters are $^5/_{16}$, $^3/_8$, $^7/_{16}$, $^1/_2$, $^9/_{16}$, $^5/_8$, $^3/_4$, and in certain cases $^7/_8$ and 1 in.

At the second session of the conference the standard dimensions for regular carriage bolts which had been developed by the Sectional Committee's Sub-Committee No. 5, were unanimously endorsed with slight changes. These standard dimensions refer to the head only and are the same as those printed in the December, 1923 issue of MECHANICAL ENGINEERING. The tolerances for these dimensions are to be added to the revised draft of the Sectional Committee's report on regular carriage bolts.

The third and fourth sessions were devoted to the study of standard dimensions for rough machine bolts and nuts, principally the width across flats of square and hexagonal bolt heads and nuts and their thickness. The Sectional Committee had already drawn up a tentative proposal which would greatly reduce the number of wrench openings as compared with present standards in this country. The schedule drawn up by the N.A.F.E.M. was slightly different in the smaller sizes to meet the special needs of farm equipment, but an agreement was reached whereby both standards were brought together by slight modifications on both sides. When this standard is finally completed a great reduction in the number of bolt-head and nut sizes will have been brought about, and as a direct consequence the number of open-end wrenches necessary to cover a given series of bolt sizes will be greatly reduced.

A Year's Progress in Industrial Standardization

DURING the past year industrial standardization has continued to develop as one of the most active and important phases of American industry. Progress has been made in the standardization of raw materials, manufacturing processes, and finished products. This is equally true whether looked at from the point of view of the factory, of the industrial or technical association, or of a national movement.

A striking development is the increased systematic use of specifications in public purchases, notably by the federal and in several of the state governments. The National Association of Purchasing Agents and the National Council of Governmental Purchasing Agents are devoting much time and attention to the subject. At the direction of Mr. Hoover, the Department of Commerce is preparing to publish a Dictionary of Specifications for Public Purchases, which will make easily available information as to what specifications are in existence, to what classes of use they apply, and how they may be obtained.

The Federal Specifications Board has completed the second year of its activity. In this the American Engineering Standards Committee has coöperated by obtaining criticisms from the various interested industries of proposed specifications of the Federal Government before the specifications are finally adopted by the Board. To date, the Board has adopted approximately ninety specifications, and the Committee has secured criticism of industry on about the same number. From these systematic efforts to bring governmental purchases in line with the best commercial practice, important economies both to industry and government are resulting.

The Division of Simplified Practice of the Department of Commerce continues to exert a most stimulating influence on the standardization movement, particularly in emphasizing the efficiency results of standardization to the business man.

Through the organization of the American Marine Standards Committee, work has been initiated in this important industry. Very little in this field has heretofore been done in this country, although very considerable activity has been going on for some time in Germany and Great Britain.

The most striking aspect of the movement for industrial standardization is the development of standardization on a national scale. More than 150 undertakings now have official status before the A.E.S.C., the national clearing house for standardization. Fifty standards have received final approval by the Committee, twenty-two of which were approved during 1923. The importance of the broadly democratic methods followed in this clearing-house work is receiving increasingly widespread recognition. In it all parties concerned with any standard—producers, consumers, and representatives of the public and government—participate (1) in deciding whether the work should be undertaken at all, (2) in formulating the standard, and (3) in its ultimate approval. Thus the industries are developing and using such standards as best fit their needs, without danger of such technical industrial matters becoming subject to legal enforcement or to governmental pressure. Is it not probable that many other of our important industrial problems will find their solutions by closely analogous methods?

In July the second conference of the national industrial standardizing bodies was held in Switzerland, where thirteen of the more important industrial nations of Europe and American were represented. Important progress was made in developing coöperation between the various national bodies, particularly in regard to the early release to each other of information on work in progress. Information on the status of all projects in hand is now regularly interchanged between the various bodies. Provision was made for continuing the work of the conference on the many problems of common interest through a continuing loose-knit organization.

There are now national industrial standardizing organizations in sixteen countries: Australia, Austria, Belgium, Canada, Czechoslovakia, France, Germany, Great Britain, Holland, Hungary, Italy, Japan, Norway, Sweden, Switzerland, and the United States. Of these, the work in Great Britain, Germany, and the United States is the most extensive, as would be expected from the scale of the industrial development in these countries.

The extensive standardization work going on in Germany continues to present many interesting phases. Some of these were outlined in a recent bulletin of the A.E.S.C. Practically every important manufacturing concern in that country is actively engaged in the work, and more than a thousand companies have formal standardization organizations within their own works. Approximately seven hundred national German standards have been approved by the central national standardizing body. These are only standards in which several industries are concerned. Standardization engineering is now a recognized profession in Germany. Some of the consulting engineering firms specialize on standardization work. Through their work on trade catalogs these consulting

engineers, among other things, are introducing standardization into sales policies and sales organizations.

Of interest not only in its relation to international standardization but also on account of its bearing on the use of specifications in foreign trade, is the resolution passed by the last conference of the Pan-American Union, where it was decided "that a conference on standardization of specifications of materials, tools, machinery and supplies be held. . . .with a view to reaching agreements which may be embodied in Inter-American conventions of this subject." This projected movement will be watched with great interest by American industries.

Standardization continues to play a more and more important role in the activities of trade associations. The subject is treated at length in the book on Trade Association Activities issued by the Department of Commerce during the year. It is of more than passing interest that the Supreme Court in a recent decision in regard to trade-association activities, explicitly recognized standardization as being in the public interest.

Letter Ballots on Two Standards Just Completed

The standard set of Symbols for Wiring Plans for the Electrical Equipment of Buildings recently completed by the Sectional Committee on the Standardization of Symbols for Electrical Equipment of Buildings organized for their formation has now received the designation "Tentative American Standard" by the American Engineering Standards Committee. The American Institute of Architects, the American Institute of Electrical Engineers and the Association of Electragists are the sponsors for this project and C. Kaiser is the Chairman of the Sectional Committee.

The closely allied subject of standard Symbols for Wiring Plans of Marine Installations, which is not covered by the present report of this Committee, was by general consent transferred to the Sectional Committee, for Electrical Installations on Shipboard sponsored by the A.I.E.E. H. L. Hibbard is Chairman of this last-named Committee.

The A.E.S.C. has just approved the recommendation of its Special Committee that the A.S.T.M. Specifications for Welded and Seamless Steel Pipe and Welded Wrought-Iron Pipe formerly known as A 53–21 and A 72–21 be approved as Tentative American Standards and given the serial designations B 21–1924 and B 22-1924. These specifications were approved as submitted under Rule R-4 and the American Society for Testing Materials was designated as the sole sponsor who will organize the Sectional Committee when revisions of these specifications are deemed desirable.

A. W. Whitney.[1]

Heat-Transfer Research Initiated

The importance of heat transfer was discussed at a gathering of forty engineers, physicists, and chemists held under the auspices of the National Research Council at the Engineering Societies Building, New York City, on January 29. The various phases of a much-needed investigation in heat transfer were discussed by those present, and the formation of an executive committee was authorized to outline the scope and to formulate a plan of action for such a research. The gathering expressed its wish that the executive committee immediately appoint two technical committees, one to deal with heat transmission and the other with insulation. The project will be carried out under the leadership of the National Research Council.

The Executive Committee's selection was announced on February 26 as follows:

F. Paul Anderson, Director, Research Laboratory of American Society of Heating and Ventilating Engineers, at U. S. Bureau of Mines, Pittsburgh, Pa.
W. L. Badger, Professor of Chemical Engineering, University of Michigan, Ann Arbor, Mich.
W. H. Carrier, President, Carrier Engineering Corpn., Newark, N. J.
Harvey N. Davis, Professor of Mechanical Engineering, Harvard University, Cambridge, Mass.
H. C. Dickinson, Chief Div. III, Heat and Thermometry, Bureau of Standards, Washington, D. C.
H. Harrison, Brunswick-Kroeschell Company, New York City.
F. E. Mathews, Consulting Mechanical Engineer, Leonia, N. J.
George A. Orrok, Consulting Engineer, 124 East 15th Street, New York City.
T. S. Taylor, Research Physicist, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

[1] Chairman, A.E.S.C.

Metric Standards Bill Introduced in Congress

Among the first bills introduced in the present session of Congress was the Metric Standards Bill, providing for gradual adoption of the metric units of weights and measures in merchandising. This bill was introduced in the House of Representatives by Hon. Fred A. Britten, of Illinois, and in the Senate by Hon. Edwin F. Ladd, of North Dakota.

According to the provisions of the Britten-Ladd bill, the buying and selling of goods, wares, and merchandise will be in terms of the metric units after a period of ten years. Manufacturers are to use whatever measures they choose in production, the bill providing "that nothing in this act shall be understood or construed as applying to the construction or use in the arts, manufacture, or industry of any specification or drawing, tool, machine, or other appliance or implement designed, constructed or graduated in any desired system."

Rules and regulations for the enforcement of the provisions of the act are to be made and promulgated by the United States Secretary of Commerce.

Edwin Ludlow Dead

Edwin Ludlow, former President of the American Institute of Mining and Metallurgical Engineers, died on February 10, 1924, at Muskogee, Okla., in his sixty-sixth year. Mr. Ludlow was born in Oakdale, L. I., and was graduated from the Columbia University School of Mines in 1879.

After graduation he became a supervisor of coal properties in Pennsylvania, owned by the Pennsylvania Railroad. He later became general manager of coal properties of the Choctaw, Oklahoma & Gulf Railroad in Indian Territory; then superintended the coal holdings of the Mexican Coal & Coke Company in Los Esperanza, Mexico, and in 1913 became vice-president of the Lehigh Coal & Navigation Company, a position which he relinquished in 1920 to go into business as a consulting mining engineer in New York.

Mr. Ludlow was an honorary member of the Institution of Mining and Metallurgy of Great Britain, and a member of many American technical societies.

Joseph Struthers, U.E.S. Treasurer, Dies

Joseph Struthers, treasurer of United Engineering Society since 1911 and of Engineering Foundation from the organization of its Board in 1915, died at the French Hospital in New York, February 18, 1924. Dr. Struthers was born in New York, 58 years ago and was educated in the public schools, the College of the City of New York, and Columbia School of Mines. He received the degree of Ph.D. from Columbia University in 1895, where he taught from 1885 to 1900, and subsequently had various engagements connected with mining and metallurgical engineering.

Dr. Struthers was a member of the American Institute of Mining and Metallurgical Engineers, of which he was assistant editor 1903–5, assistant secretary 1906–10, editor 1906–12, a director in 1911, and secretary 1911–12. He became secretary and treasurer of the Engineers' Club of New York in 1909, which office he held to the time of his demise. From 1918 to 1920 he was in the Ordnance Department, U. S. A.

A Correction

Through a misunderstanding the business address of J. L. Williamson was given incorrectly on page 132 of the March issue of Mechanical Engineering. Mr. Williamson, a nonmember, is connected with the railway motor department of the General Electric Co., at Schenectady, N. Y.

Library Notes and Book Reviews

Alternating-Current Armature Winding. By Terrell Croft. McGraw-Hill Book Co., N. Y., 1924. Cloth, 6 × 8 in., 352 pp., illus., diagrams, tables, $3.

This is a practical book for those interested in winding or rewinding alternating-current stators. It does not discuss design nor contain any advanced mathematics. Starting with the necessary definitions and classification of machinery, directions are given for rewinding machines for their original conditions, for reconnecting windings to suit changed conditions, and for unusual connections. A section on testing windings and locating faults is included. The final section consists of 165 diagrams of standard connections for single-phase, two-phase and three-phase windings.

Appraisers' and Adjusters' Handbook. By William Arthur. U. P. C. Book Co., New York, 1924. Fabrikoid, 5 × 7 in., 616 pp., diagrams, tables, $5.

A handbook of data for engineers, owners of real estate, and others interested in the valuation of buildings and structures. Part one deals largely with general principles, square-foot and cubic-foot costs, and the approximate estimation of the cost of buildings. Part two explains how the cost of the various details may be found. Included in it are many useful tables showing the amount of work done per hour in building work of various kinds.

Automobile Repairing. By Ben G. Elliott and others. McGraw-Hill Book Co., N. Y., 1924. Cloth, 5 × 8 in., 431 pp., illus., diagrams, $3.

Presents, in a volume of reasonable size, the fundamental principles employed in the various operations of repairing the gasoline automobile and its equipment. Intended for use as a text or reference book by repairmen, students and owners of cars. Part one treats of repair work. Part two contains information on shop tools, equipment, processes, and methods for persons without shop experience.

Blasting with High Explosives. By W. Gerard Boulton. Isaac Pitman & Sons, London & N. Y., 1923. Cloth, 5 × 7 in., 108 pp., illus., diagrams, tables, $1.50.

The aim of this work is to call attention to the great superiority of high explosives over black powder, and to give those unaccustomed to their use simple, clear directions for using them safely and economically. The directions cover the selection of the proper explosives, methods of handling and firing them, and the use of explosives in tunneling, mining, under water, and for various other purposes.

Die Dampfturbinen—Vol. 3. By Const. Zietemann. Walter de Gruyter & Co., Berlin and Leipzig, 1924. Boards, 4 × 6 in., 136 pp., illus., diagrams, $0.30.

The first section of this volume treats concisely of turbine regulation and the design of regulating apparatus. The second section describes briefly the modern types of turbines, and section three discusses turbines for special purposes. Section four discusses condensing equipment for steam turbines. The concluding section reviews the field for the steam turbine and compares turbines with reciprocating engines.

Economics of Motor Transportation. By George W. Grupp. D. Appleton & Co., N. Y., 1923. Cloth, 6 × 9 in., 414 pp., illus., $4.

This book attempts to cover the entire field in as much detail as is possible within the limits of a single volume, with due regard to the needs of students of transportation, manufacturers of motor vehicles, and owners or prospective owners of trucks. Attention is concentrated on the principles involved in road transport and on the methods of applying these principles successfully. Among the subjects discussed are the replacement of horse wagons, selection of trucks, track operation, loading, cost accounting and omnibus transportation.

Galvanomagnetic and Thermomagnetic Effects. By L. L. Campbell. Longmans, Green & Co., N. Y., 1923. (Monographs on Physics.) Cloth, 6 × 9 in., 311 pp., diagrams, $5.25.

This monograph reviews concisely, yet in detail, the historical, experimental, and theoretical accounts of that family of galvanomagnetic and electromagnetic phenomena that are the lineal offspring of the Hall effect. Includes, in addition to the Hall effect, those known as the Ettingshausen, Nernst, and Righi-Leduc effects. An extensive bibliography is included.

Industrial Health. By George M. Kober and Emery R. Hayhurst, editors. P. Blakiston's Son & Co., Philadelphia, 1924. Cloth, 6 × 10 in., 1184 pp., $15.

This work, a revised and extended edition of Kober and Hanson's Diseases of Occupation and Vocational Hygiene, is a concise encyclopedia of the subject, amply provided with references to the recent literature. Over thirty specialists have contributed to it. Part one deals with the general principles of maintaining health in industry. Part two considers the vocational hygiene of certain industries and callings, such as mining, metallurgy, and railroading, which are sufficiently important to deserve special attention. Part three pertains to specific occupational diseases, the result of exposure to poisons, infections, and conditions and methods of industrial applications. Part four covers the systematic occupational diseases. Part five deals with the general principles of industrial health administration.

Life of Francis Amasa Walker. By James Phinney Munroe. Henry Holt & Co., N. Y., 1923. Cloth, 6 × 9 in., 449 pp., port., $4.

General Walker has many claims to fame as a soldier, an economist and a public official, but to engineers he is best known for his work at the Massachusetts Institute of Technology, of which he was president from 1881 to 1897. Mr. Munroe's biography, published twenty-five years after General Walker's death, gives a full account of his busy life and a careful estimate of his contributions to the reforms in government, in education, and in social administration for which he labored.

Modern Electro-Plating. By W. E. Hughes. Henry Frowde, and Hodder & Stoughton, London, 1923. (Oxford Technical Publications.) Cloth, 6 × 10 in., 160 pp., plates, tables, $5.35.

This book is not intended as a textbook but as a help to platers, chemists and engineers in search of practical, modern information on the electrodeposition of the metals of general interest in engineering. The first chapter is a general review of the subject. This is followed by chapters on theory, on the preparation of work, on the deposition process and on finishing. The various metals, iron, nickel, zinc, lead, tin, chromium and copper are then considered at length. A chapter on the structure of deposited metal, and one on recommended reading end the volume. Numerous references and bibliographies add to the value of the book.

Preparation of Reports; Engineering, Scientific, Administrative. By Ray Palmer Baker. Ronald Press Co., New York, 1924. Cloth 5 × 8 in., 468 pp., illus., diagrams, $3.50.

Dr. Baker's work, while intended primarily for students, contains information on the preparation of reports which has never before been brought together and which will be usefuif or reference to those engaged in active practice. Various types of reports—information reports, examination reports, recommendation reports, progress reports and research reports—are analyzed systematically. The reports used are actual examples, selected from a great variety.

Principle of Relativity. By H. A. Lorentz, A. Einstein, H. Minkowski & H. Weyl. Dodd, Mead & Co., New York, 1923. Cloth, 6 × 9 in., 216 pp., diagrams, $4.00.

A translation of Das Relativitätsprinzip, which appeared several years ago. The papers here collected are by some of the foremost students of the theory, and the collection is intended chiefly to exhibit the way in which the theory gradually grew under the stimulus of physical experiment.

Railway-Signalling: Mechanical. By F. R. Wilson. Isaac Pitman & Sons, London and New York, 1923. (Pitman's Technical Primers.) Cloth, 4 × 7 in., 109 pp., illus., diagrams, $0.85.

This introduction covers very clearly the practice of signalling on British railroads. The lay-out of signal systems, interlocking

the connection of cross-overs and the mechanical apparatus are described, and instructions for preparing plans are given.

RESEARCH INFORMATION SURVEYS ON CORROSION OF METALS, Nos. 1-3; Nickel, Aluminum, Copper. By National Research Council. Research Information Service, Washington, D. C., 1923. Paper, 8 × 11 in., 3 vols. in one, $2.00.

These three bulletins review our knowledge of resistance of nickel, aluminum and copper to various chemicals. The information is definite and the authorities for the data are given in the extensive bibliographies which accompany each monograph. The work will be valuable to everyone interested in the use of these metals.

RECENT DEVELOPMENTS IN ATOMIC THEORY. By Leo Graetz. E. P. Dutton & Co., N. Y., 1922. Cloth, 6 × 9 in., 174 pp., illus., diagrams, tables, $3.50.

Six lectures which explain the steps that lead up to present views about atoms and illustrate the advances in the explanation of many phenomena which have been made by means of these views. The book is intended not only for students of physics and chemistry but also for general readers of a scientific turn of mind.

LA TELEGRAPHIE SANS FIL. By Julien Verdier. Gauthier-Villars et Cie., Paris, 1924. Paper, 6 × 9 in., 412 pp., illus., diagrams, 35 fr.

This work is not a text on radio practice, but an account of the development of radio communication, intended for the general reader, in which the principles are explained and the great variety of uses to which it is being put are set forth. It gives for the first time, the author says, an account of the services rendered by radio during the World War; including among other items the hitherto unpublished official radiotelegrams concerning the armistice.

TEXTBOOK OF INDUSTRIAL COST ACCOUNTING. By Paul M. Atkins. McGraw-Hill Book Co., N. Y., 1924. Cloth, 6 × 9 in., 396 pp., illus., $4.

This textbook, based on the courses given by its author in the University of Chicago, is intended for students who have already studied business administration, factory management, and accounting. The method of instruction differs from that now commonly in use, and is better suited, in the opinion of the author, to give the student an understanding of the practical difficulties that are likely to arise in cost accounting, as well as of the theoretical principles involved.

Coal-Storage Systems

(Continued from page 198)

pile was insufficient to keep down the rise in temperature, then spontaneous combustion would result. If that theory was correct, then the storage of fine coal or of powdered coal would be a much more dangerous proposition than would be the storage of coal in very large lumps.

In reference to the burning of powdered coal in comparatively large sizes, there was nothing about the suspension of coal that made for efficiency. The real reason for the efficiency in powdered-coal burning was due to the fact that the coal was so finely pulverized that the air required for its oxidation was in the immediate vicinity of the coal; and the reason large furnaces were needed now for powdered-coal burning was simply because we still burned the coal in suspension and did not have the air supply in the immediate vicinity of the coal. The question of volume had absolutely no connection with combustion. The reason large volumes were needed in powdered-coal furnaces was because it was necessary to allow the coal to find the air with which it was eventually going to combine.

N. E. Funk[1] said that in storing with cranes, just one layer was spread over the whole area of ground provided for storage, then a scraper hauled by a tractor was dragged over the pile until it became perfectly level, mixing up the large lumps and the fines. This procedure was repeated layer by layer. His company had over 200,000 tons of coal stored that way in piles from 30 to 60 ft. wide at the base and from 15 to 30 ft. high, and had not as yet had a fire in a year and a half. The pile should not be ventilated. If air could be prevented from getting to the coal by tight packing the coal could not oxidize, and if it could not oxidize it could not burn. It was, however, true that there had been some small fires along the edge of the pile, but there the men with the tractors had not been careful and the packing was not good. There were little holes in the bottom at such places so that the air could come up through the fine and coarse coal, and there had been little circles of fire at those points. Therefore one of the big things in storing coal was to keep the air from getting to it.

Chairman Abbott said that for several years past the Commonwealth Edison Company had merely put its coal in storage and forgotten about it. They had put no ventilating pipes in and used no means for taking temperatures. All they had done was to refrain from putting fine coal in the pile; only lump coal above an inch and a quarter went into storage. It was the fine coal which caused fires. Coal began to oxidize the moment it was taken from the mine and exposed to the air. That oxidation took place naturally on the surface of the coal only. A lump of coal one inch in diameter had a certain surface area, perhaps something like three square inches; grinding that lump into pieces one-hundredth of an inch in diameter increased the surface a hundredfold and the heating was increased correspondingly, provided air was gotten to it. When coal was stored, coarse and fine together, then along the side of the pile and down to depth of five feet or thereabouts there occurred such a mixture of fine and coarse that there was enough oxygen supplied and not sufficient ventilation to keep the temperature down, and there was where the heating would begin. The correct formula for storing coal so it would not take fire was: Put in nothing but fine coal, or put in no fine coal.

E. N. Trump[1] said that his company formerly thought it a very difficult matter to store coal of any kind because they had had fires continually. They now had storage piles under bridges in which they put 80,000 tons at a time and experienced no trouble. No precautions were taken except to see that the fine coal and the coarse coal were distributed evenly so as not to become segregated. If coal was dumped on the top of a conical pile the large coal ran down the outside and the fine stayed in the middle, and the air seemed to get at the outside and start the fire around the lower edge. Very seldom did it start in the middle of the pile. With even distribution, however, there was rarely, if ever, any difficulty encountered.

O. P. Hood, author of the first paper to be presented at the session, said that Mr. German had stated that in the two piles of coal he had made the coal was the same. It went into storage at about the same time; it was piled to substantially the same height, etc. But one pile was crushed, and the other was not. There seemed to be some doubt, however, as to the reason why one pile took fire and the other did not. Apparently, the trend of the presentation was that these ventilating holes had something to do with the case. It seemed a matter of question as to whether it was the crushing or the piling or the holes or the collars that were put on the holes that prevented fires.

In regard to the matter of ventilating a coal pile, he believed that the Canadian Pacific had practiced that, and perhaps still practiced it, storing large quantities of coal and putting holes down through the pile from 18 inches to two feet apart. It would seem that holes that were four or five feet apart played a small part in the program.

Regarding spontaneous combustion in powdered coal, it was necessary to have carbon, and oxygen supplied to that carbon. Powdered coal lay together so close, so tight, that the oxygen in the interstices was soon used up. It would take an exchange of air somewhere in the neighborhood of from 20 to 40 times to fill those interstices to give oxygen enough to raise the temperature of the coal to a dangerous point. Without that exchange of air there would be no rising temperature and it was extremely difficult to get such an exchange of air in a powdered-coal mass. Powdered coal usually took fire from some outside source. That is, burning coal was injected into the mass, or it was in corners where the amount of powdered coal was relatively small compared to the amount of air and the movement of air, or in pipe lines where powdered coal was being moved by air and there was plenty of air.

[1] Operating Engr., Phila. Elec. Co., Philadelphia, Pa. Mem. A.S.M.E.

[1] Pres., Stump Una-Flow Eng. Co., Syracuse, N. Y. Mem. A.S.M.E.

THE ENGINEERING INDEX

Registered United States Great Britain and Canada

Exigencies of publication make it necessary to put the main body of The Engineering Index (p. 127-EI of the advertising section) into type considerably in advance of the date of issue of "Mechanical Engineering." To bring this service more nearly up to date is the purpose of this supplementary page of items covering the more important articles appearing in journals received up to the third day prior to going to press.

AIRPLANE ENGINES

Thermodynamics. The Thermo-Dynamics of Aircraft Engines, H. R. Ricardo. Roy. Aeronautical Soc.—Jl., vol. 28, no. 158, Feb. 1924, pp. 49–75 and (discussion) 75–87, 17 figs. Deals with such factors as change of specific heat, interchange of heat, influence of latent heat, pre-burning, flame temperature and range of burning, influence of temperature and pressure of compression, stratified charge and supercharging.

AIRPLANES

Douglas World Cruiser. The Douglas World Cruiser Described. Aviation, vol. 16, no. 8, Feb. 25, 1924, p. 205, 1 fig. Conventional-type biplanes which carry large load in proportion to their own weight giving them a long non-stop flying range, and yet they can be maneuvered into and out of small landing areas.

Lift and Drag. The Elements of the Lanchester-Prandtl Theory of Aeroplane Lift and Drag. Engineering, vol. 117, nos. 3027, 3028, 3030, 3032 and 3035, Jan. 4, 11, 25, Feb. 8 and 29, 1924, pp. 1–3, 35–37, 100–102, 169–171 and 258–260, 34 figs. Describes development of Lanchester's views into rational and practical theory of airplane by Prof. Prandtl.

AIRSHIPS

Aerodynamical Characteristics. The Aerodynamical Characteristics of the Airship as Deduced from Experiments on Models, with Application to Motion in a Horizontal Plane, R. Jones. Roy. Aeronautical Soc.—Jl., vol. 28, no. 158, Feb. 1924, pp. 88–150, 21 figs. Considers aerodynamic forces directly measured in wind channel, that is, forces due to translation; directs attention to examination of forces due to rotation, and to combined forces and determination of positions of equilibrium in curvilinear flight with rudders inclined at various angles; and considers distribution of normal pressures over hull and fins in steady motion.

AUTOMOBILES

Specifications and Design. Trends in Passenger Car Design. Automotive Industries, vol. 50, no. 8; Feb. 21, 1924, pp. 393–418, 9 figs. Statistics on prices, progress of design shown by trend studies; American passenger-car chassis specifications; engine specifications; taxicab, steam-passenger-car and gasoline-railcar specifications; British and Continental European specifications.

BOILER FURNACES

Small-Sized Anthracite. Burning Small Sizes of Anthracite, A. A. Cary. Power, vol. 59, no. 9, Feb. 26, 1924, pp. 326–328, 3 figs. Discussion prompted by paper by A. R. Mumford read before A.S.M.E. and published in Feb. 19, 1924, issue of same journal.

BOLTS

Flange, Initial Tension in. Effect of Initial Tension in Flange Bolts, M. D. Casler. Am. Mach., vol. 60, no. 10, Mar. 6, 1924, pp. 369–370, 1 fig. Mathematical treatment for determination of stresses in bolts under various load conditions; method of deriving formulas; numerical example to illustrate solution.

BOXES

Shipping Containers. Formulas for Shipping Box Construction, M. L. Oglesby. Mgt. & Administration, vol. 7, no. 3, Mar. 1924, pp. 323–328, 8 figs. Forces acting and sizes of material required to withstand them.

CENTRAL STATIONS

Kearny Plant, N. J. Work on Kearny Plant Progressing. Power Plant Eng., vol. 28, no. 5, Mar. 1, 1924, pp. 310–311, 2 figs. Additional details concerning plant on Hackensack River, N. J., being built by Pub. Service Elec. Power Co., which will add new link to chain of superpower stations in East.

Remodeling. Revamping Municipal Electric plant at Hannibal, Mo. Power, vol. 59, no. 11, Mar. 11, 1924, pp. 394–397, 4 figs. Revamping a Corliss-engine condensing plant and installing additional boiler, new turbo-generator to carry bulk of load and coal and ash-handling equipment, resulted in reducing steam consumption per unit of output 40 per cent, amount of coal burned in nearly same proportion and 24-per cent reduction in labor costs.

CONVEYORS

Automobile Plants. Power Conveyors in the Automobile Plant. Machy. (N. Y.), vol. 30, no. 7, Mar. 1924, pp. 541–543, 4 figs. Describes several examples of modern conveyor installations, link chains and sprockets for which were supplied by Link-Belt Co., Chicago.

CRANES

Overhead vs. Gantry. Comparative Cost of Electric Traveling and Gantry Cranes, Wm. L. Laing. Am. Mach., vol. 60, no. 9, Feb. 28, 1924, p. 318. Assumption and figures which, when corrected to suit local conditions, can be used as guide.

DIESEL ENGINES

Bethlehem. Largest Two-Stroke-Cycle Diesel Built in America. Power, vol. 59, no. 11, Mar. 11, 1924, pp. 406–408, 6 figs. Bethlehem 2900-hp. two-stroke-cycle engine has no cylinder head; scavenging pumps are at side of frame, scavenging valves in top of cylinder.

FLYWHEELS

Stress Determination. The Stresses in a Uniformly Rotating Fly-Wheel, A. J. Sutton Pippard. Instn. Mech. Engrs.—Proc., no. 1, 1924, pp. 25–42 and (discussion) 43–51, 7 figs. Author uses method of analysis founded on certain theorems of Castigliano, which leads to formulas of straightforward and easily applied type; investigation dealing with stresses in ring subjected to system of radially applied forces is given in appendix.

FOUNDRIES

Labor-Saving. Mechanical Foundry Minimizes Labor, J. E. McDonald. Iron Age, vol. 113, no. 9, Feb. 28, 1924, pp. 633–637, 9 figs. Output per man trebled in new plant of Lavelle Foundry Co., Anderson, Ind., features of which are three stories, gravity flow, controlled conveyors and specialized design. See also description by D. M. Avey in Iron Trade Rev., vol. 74, no. 9, Feb. 28, 1924, pp. 601–606, 10 figs.; and Foundry, vol. 52, no. 5, Mar. 1, 1924, pp. 167–174, 16 figs.

GEARS

Enveloping Teeth. "Enveloping" Gear Teeth. Engineering, vol. 117, no. 3035 Feb. 29, 1924, pp. 257–258, 4 figs. Refers to type of tooth which, after exhaustive comparative tests, has been definitely adopted by Vickers Ltd., as Vickers, Bostock & Bramley "enveloping" gear teeth; gives results of tests.

Helical. Interference between Helical Gears on Parallel Shafts, J. B. Arnold. Machy (N. Y.), vol. 30, no. 7, Mar. 1924, pp. 538–540, 3 figs. Formulas are deduced for redesigning a helical ring gear and pinion to meet requirements of fixed ratio and center distance.

Ratios, Calculation of. Super-accuracy in Gear Ratios, T. M. Lowthian and W. Owen. Engineer, vol. 137, no. 3555, Feb. 15, 1924, pp. 164–166. Describes simple method of calculating gear ratios.

HYDRAULIC TURBINES

Large, Construction of. Building Hydraulic Turbines of Unusual Size, E. T. Spidy. Am. Mach., vol. 60, no. 10, Mar. 6, 1924, pp. 345–349, 15 figs. Equipment and methods of Dominion Engineering Works near Montreal; layout plate exceptionally large; heavy machine tools of various kinds; taking portable machines to work; balancing rotating parts of great weight.

INDUSTRIAL MANAGEMENT

Cost Control by Budget. Cost Control by Budget, Thos. B. Fordham and E. H. Tingley. Mgt. & Administration, vol. 7, no. 3, Mar. 1924, pp. 291–294, 1 fig. Points out advantages to be gained by budget analysis; operating factory divisions by budget.

INDUSTRIAL MOBILIZATION

Plans, United States. Plans for Industrial Mobilization, L. W. Moffett. Iron Age, vol. 113, no. 10, Mar. 6, 1924, pp. 707–709, 1 fig. Program of U. S. War Department covers allocations, specifications, contracts, etc.; pledge of Iron & Steel Inst.; emergency reserves; procurement planning; control of labor.

IRON CASTINGS

Gray-Iron, Annealing. The Soft Annealing of Gray Iron Castings (Ueber das Weichglühen von Grauguss), E. Schüz. Stahl u. Eisen, vol. 44, no. 5, Jan. 31, 1924, pp. 116–118, 2 figs. Results of tests on time of annealing and speed of cooling of silicon-poor, thin-walled castings, for purpose of obtaining high degree of softness; metallographic determination of phenomena through quenching tests; practical results.

Locomotive. Making Locomotive Castings, H. E. Diller. Foundry, vol. 52, nos. 2, 3 and 4, Jan. 15, Feb. 1 and 15, 1924, pp. 53–60, 89–95 and 137–143, 27 figs. Jan. 15: Survey of objects and problems of foundry of Baldwin Locomotive works, and description of molding and core work. Feb. 1: Description of molding and core work for making locomotive cylinders. Foundry operations and control, and study of foundry layout. Feb. 15: Supervision by contractors.

JIGS

Clamping Devices for. Swinging-leaf Clamping Devices, F. Server. Machy. (N. Y.), vol. 30, no. 7, Mar. 1924, pp. 544–546, 7 figs. Hinged cover with equalizing clamp; swing cover adapted for holding bushings; methods of clamping hinged covers; hinge pin with vertical adjustment; hinged-cover fixture for lathe chuck.

MACHINE TOOLS

Feet and Bases. Design of Machine Tool Feet and Bases, F. Horner. Machy. (N. Y.), vol. 30, nos. 6 and 7, Feb. and Mar., 1924, pp. 450–453 and 508–510, 12 figs. Typical designs for different classes of machines.

MATERIALS HANDLING

Shop Transportation. Reducing the Cost of Shop Trucking, Robt. T. Kent. Mgt. & Administration, vol. 7, no. 3, Mar. 1924, pp. 317–322, 6 figs. Methods which effected big savings in plants where adopted.

MILLING

Fixtures. Fixtures for Production Milling, A. A. Dowd. Machy. (N. Y.), vol. 30, no. 7, Mar. 1924, pp. 521–523, 5 figs. Examples of fixture design are given in detail to illustrate modern trend in locating and clamping methods and in general features of construction.

OIL ENGINES

Cold-Starting. A Cold-starting Oil Engine. Engineer, vol. 137, no. 3555, Feb. 15, 1924, pp. 180–181, 9 figs. New vertical oil engines made by Ruston & Hornsby, Lincoln, England, of 4-cycle, mechanical injection, high-compression type, which can be started when quite cold without use of blow lamp or any other heating device.

PNEUMATIC TOOLS

Repair and Upkeep. Repair and Upkeep of Pneumatic Tools, R. W. Wilson. Engineering, vol. 117, no. 3033, Feb. 15, 1924, pp. 219–220, 7 figs. Considers what is necessary to maintain in efficient operation and in economical service the pneumatic tools commonly used in workshops and shipbuilding yards. Paper read before Instn. Mech. Engrs.

POWER TRANSMISSION

Wave. Wave Transmission of Power, H. Moss. Instn. Mech. Engrs.—Proc., no. 1, 1924, pp. 1–14 and (discussion) 15–24, 6 figs. Account of elements of Constantinesco system of hydraulic transmission, and results of tests; elements of theory; power and efficiency calculations.

PULVERIZED COAL

Preparation and Utilization. Pulverized Coal: Its Preparation and Utilization, R. Jackson. Engineer, vol. 137, no. 3555, Feb. 15, 1925, p. 179. Notes on pulverizers; pendulum mills; storage bins, feeders and burners. (Abstract.) Paper read before Coventry Eng. Soc.

PUMPS, CENTRIFUGAL

Turbine, for Boiler Feeding. Turbine Pump for Boiler Feeding, C. H. S. Tupholme. Power Plant Eng., vol. 28, no. 5, Mar. 1, 1924, pp. 279–280, 4 figs. Recent installations in Great Britain indicate growing use of turbine pump.

REFRIGERATING MACHINES

Ammonia Condensers. Investigations of Ammonia Condensers, T. Shipley. Power, vol. 59, no. 10, Mar. 4, 1924, pp. 364–367, 4 figs. Calls attention to important points in ammonia condensers, and discusses development of design of Hestonville condenser and reasons for assuming that such design would give better results than other types of condensers. (Abstract.) Paper read before Nat. Assn. Practical Refrig. Engrs.

SCREENS

Perforated Metalware Manufacture. Production of Perforated Metalware. Iron Age, vol. 113, no. 10. Mar. 6, 1924, pp. 701–705, 11 figs. Routing of materials and special punching arrangements features of Hendrick plant at Carbondale, Pa.; steel and manganese bronze principal materials.

STEAM POWER PLANTS

Combined Diesel and Boiler Plant. Oil Engines Practical Even if Process Steam Be Needed, J. S. LeClercq. Power, vol. 59, no. 9, Feb. 26, 1924, pp. 322–323, 2 figs. Dallas Oil & Refining Co. uses Diesel for power and boilers for process steam; results show considerable saving in power costs.

St. Louis, Mo. Power for the Bridge & Beach Mfg. Co., Power Plant Eng., vol. 28, no. 5, Mar. 1, 1924, pp. 267–271, 8 figs. New power plant of stove manufacturing plant in St. Louis as example of small power-plant construction; steam is generated in three O'Brien, Heine-type boilers equipped with Laclede-Christy chaingrate stokers; electric power is generated by two 440-volt, 3-phase a.c. generators.

STEAM TURBINES

Blading. Steam Turbine Blading. Power, vol. 59, nos. 6, 7, 8 and 9, Feb. 5, 12, 19 and 26, 1924, pp. 200–204, 11 figs.; 251–254, 9 figs.; 293–296, 6 figs.; and 329–330, 2 figs. Describes commercial turbine blading, telling how to distinguish impulse from reaction types, why some impulse blades are unsymmetrical and what general conditions govern blading materials; different types of blading, and recent improvements.

STOKERS

Underfeed. Underfeed Stokers and Economy in Coal, Jos. G. Worker. Mgt. & Administration, vol. 7, no. 3, Mar. 1924, pp. 287–290, 7 figs. Development, operating principles, and applications to power production. (Abstract.) Address before Chicago Section of A.S.M.E.